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CHOOSING LEGUMES AND PERENNIAL GRASSES

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CHOOSING LEGUMES AND PERENNIAL GRASSES

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Many letters are received annually by the Iowa Agricultural Experiment Station requesting information on the different legumes and grasses. This publication has been prepared to answer the more important questions pertaining to the choice of legumes and grasses for different uses and conditions.[2]

Legumes of greatest value for different uses or soil conditions in Iowa are **(1) alfalfa, (2) medium red clover, (3) mammoth red clover, (4) alsike clover, (5) white clover, (6) the biennial white and yellow sweet clovers, (7) hubam clover,** (the annual white sweet clover) **(8) Korean lespedeza, (9) dalea and (10) soybeans.** A discussion of soybeans is largely omitted in this publication since the growing of this crop is entirely different from that of the others.[3]

The six grasses of the greatest economic importance in Iowa, considering seed supply, usefulness and soil adaptation, are **(1) Kentucky bluegrass, (2) timothy, (3) red top, (4) brome, (5) reed canary and (6) orchard.** Others which may be grown occasionally are **meadow fescue, tall oat, slender wheat, and crested wheat grasses.**

SOIL ADAPTATION[4]

Tillable soils generally can be made suitable for the legumes and grasses, however exacting in their lime, fertility or drainage requirements. Farm owners and operators seeking the

[1] This bulletin and a companion publication (now being prepared), representing work on projects 143, 149, 152, 170, give the results of investigations conducted by the Iowa Agricultural Experiment Station through a period of years and the results of personal observations on Iowa farms and visits with the operators through 20- and 25-year periods by the senior and junior authors, respectively, while they have been members of the staff of Iowa State College.

[2] A companion publication, "Establishing Legumes and Perennial Grasses," will be issued soon and may be had by writing to the Bulletin Office, Ames, Iowa. Since the information in a publication including a number of legumes and grasses is necessarily limited, the reader is advised to consult other bulletins giving more specific information on such crops as are of particular interest to him. A source list of available publications is given on page 149.

[3] Information on this crop is reported fully in Iowa Agr. Exp. Sta. Bul. No. 309.

[4] Bulletins and county soil survey reports dealing with practically all phases of Iowa soil management and improvement are available at the Bulletin Office, Iowa State College, Ames, Iowa.

most efficient crop production will ultimately desire to have their farms in such condition. This often requires a soil building program continued through a period of some years.

The farm operator whose land is deficient in one or more ways, and who desires to economize in immediate expense, has considerable latitude in his choice of suitable crops. As he proceeds with his soil improvement program, however, he will find it easier to obtain stands, and will get higher yields even of those legumes and grasses that can be grown without soil improvement.

SOIL ADAPTATION OF THE LEGUMES

The most suitable soils for alfalfa and all clovers are fertile, well supplied with organic matter, well drained, and containing sufficient lime. The Iowa grower, however, has available to him legumes which differ considerably in their soil requirements.

Alfalfa demands a reasonably fertile, well drained soil, neutral or slightly alkaline (not acid). Manure or phosphorous is recommended for soils that produce less than 50 bushels of corn per acre and they may prove profitable on more fertile soils. A good practice, particularly on soils low in organic matter, is to grow sweet clover in advance of alfalfa, plowing the sweet clover under in the summer of the second year of growth.

Biennial and hubam sweet clovers demand a neutral or alkaline soil but can be grown successfully on less fertile soils and soils with somewhat poorer drainage than are required for alfalfa. Sweet clover is commonly seen growing luxuriantly on clay banks, well supplied with lime, where other clovers or alfalfa will not grow because of lack of readily available nutrients. Sweet clover, in establishing inoculating bacteria, and adding organic matter, makes an excellent conditioning crop for alfalfa. Also, sweet clover is less likely to winterkill in the poorer drained areas of a field than is alfalfa. Sweet clover is well suited for preparing alkaline soils for other crops after the soil has been drained. It is particularly resistant to the high salt content of alkaline soils and produces heavy growths, which, when plowed under, increase the state of productivity in such soils.

Fig. 1. Twenty sweet clover plants (first-year growth) in each group: (left) no lime and no inoculation; (middle) inoculation but no lime; (right) both lime and inoculation. Both sweet clover and alfalfa require a soil well supplied with lime, while it is necessary to inoculate most legumes when grown on a given soil for the first time.

Observations in Iowa and elsewhere have led to the belief that **biennial yellow sweet clover** may be a little more tolerant of a slightly acid soil than **biennial white.** The differences are not sufficiently pronounced, however, to justify the seeding of yellow sweet clover on acid soils.

Medium red clover is somewhat similar to alfalfa in its soil requirements but can be grown with success on soils showing considerably more acid. It will do better, however, if the soil is limed. Mammoth red clover is considered to be better suited to sandy soils than medium red but is grown comparatively little.

Alsike is the least exacting of the meadow clovers suitable for Iowa in its lime and drainage requirements and can often

be grown on soils too acid or too wet for sweet clover, red clover or alfalfa. Because of its tolerance of inadequate drainage, alsike, in mixture with timothy, is usually recommended for peat soils. The ideal situation for alsike, however, is similar to that of the other legumes.

White clover, the common clover of pastures and lawns, is more universal in its soil adaptation than any of the other clovers. It is fairly tolerant of acid soil and grows on most any soil not extremely low in fertility. It is particularly at home in moist situations and grows well in areas semi-poorly drained but does not withstand prolonged periods of drouth. It is the natural companion of Kentucky bluegrass.

It has been observed frequently that legumes sensitive to soil acidity are somewhat more tolerant of a slight acid condition of the soil if the soil is fertile—well supplied with organic matter, nitrogen, phosphorous and potassium. Even on such soils, however, better growth results after lime has been applied.

The annual legumes, **Korean lespedeza, soybeans,** and **dalea** are the most acid soil tolerant of the legumes suitable for Iowa conditions. Korean lespedeza, because of its failure to reseed regularly and small growth farther north, is recommended only for the south one-third of Iowa. Dalea, with proper seed treatment, apparently can be grown in all parts of the state. Sericea, the acid soil perennial lespedeza, recommended highly for the south, appears not to be sufficiently winter hardy for Iowa use except on an experimental basis and then only on soils too acid and low in fertility for alfalfa.

In the southern states Korean lespedeza has been recommended for the poorer soils as well as those that are acid. Like most other cultivated plants, however, it makes comparatively little growth on the poorest soils. Nevertheless, under such conditions it is much better than growing no legume at all, and with succeeding crops the growth is improved. Excellent growths have been observed in Iowa on some soils unsuited to other legumes while in other instances the growths have been disappointing.

Dalea is well suited for green manure on acid, infertile soils where the clovers do not succeed. The great majority of seed-

ings which have been made have not given satisfactory results, either in stand or growth, and for a time this was believed to indicate marked limitations in soil adaptation. Recent studies, however, indicate the presence of a seedling disease organism in many soils which can be controlled with seed treatment.

SOIL ADAPTATION OF THE GRASSES

In general the grasses are not as exacting in their lime and drainage requirements as the legumes. **Kentucky bluegrass,** the standard pasture grass, and **timothy,** the standard meadow grass, are adapted to nearly all soils of the state, except those poorly drained, or extremely low in nitrogen, or extremely high in acidity. Both grasses give highest yields on fertile soils well supplied with lime, but both grow well on moderately acid soils.

Red top is best suited to soils too acid, too low in nitrogen and other nutrients, and too poorly drained for Kentucky bluegrass or for timothy. It will even survive in shallow ponds which later become dry. Soils which will not support Kentucky bluegrass and have been taken over by weedy, non-edible grasses often will grow red top fairly satisfactorily if disked or plowed and seeded with this grass. In southern Iowa it is desirable to seed Korean lespedeza in mixture with red top on acid soils low in fertility.

Brome grass has about the same fertility and lime requirements as Kentucky bluegrass and timothy and is among the more drouth-resistant of the cultivated grasses.

Reed canary is by far the most valuable grass available for poorly drained, semi-swampy soils on which water may stand during several months of the year. It is also the most drouth resistant, however, of all species tested at the Iowa Station on well drained, upland soils.

Orchard grass is similar in soil requirements to Kentucky bluegrass and timothy. It grows fairly well on wet soils but prefers an average amount of moisture. It withstood heat and drouth the poorest of any of the grasses in test at the Iowa Station in the unusually dry summer of 1927. As its name suggests, this grass probably is the best meadow or pasture grass known for seeding in shady, wooded areas. In 1927 it produced a strong, thrifty growth in the shade of second year

sweet clover, whereas it gave practically no growth in sunny locations.

Meadow fescue has much the same soil adaptation as timothy. It is not well adapted to poor or sandy soils and grows best on fertile soils plentifully supplied with moisture. In tests at the Iowa Station it has thrived fairly well on upland, 60-bushel corn soils, but in the dry summer of 1927 was the poorest of any of the grasses except orchard, and yielded no second crop. It is said to be as well adapted to shady situations as orchard grass.

Tall oat grass, said to be one of the best grasses for poor land, succeeds well on fertile loams and on dry, sandy soils. It is reported to be among the more drouth resistant of the cultivated grasses. At the Iowa Station it was one of three out of seven grasses that produced a second crop in the unusually dry summer of 1927. It is not adapted to wet, poorly drained soils nor shady locations.

The **wheat grasses—slender** and **crested**—have produced fairly good crops on fertile soils at the Iowa Station but do relatively better in the drier sections of the West.

CHOICE OF LEGUMES AND GRASSES

Choice of legumes and grasses depends largely upon five interrelated factors: (1) soil adaptation, (2) use to be made of the product, (3) yield and quality of the forage, (4) topography and rotation needs of the farm, and (5) cost and availability of seed. Certain legumes or grasses are outstandingly superior for hay, others for pasture and perhaps still others for green manure. Some of them are superior when grown for two or more of the uses indicated while still others may best be used in mixtures for one or more of the three uses.

Because of higher yields, higher feeding value and higher nitrogen and protein content the clovers and alfalfa are much preferred to the grasses for hay, pasture and green manure on soils adapted to both the legumes and grasses. The legumes have another outstanding advantage in that, when inoculated, they can utilize nitrogen from the air for their growth and thus enrich the soil in nitrogen when returned to the land in the form of either animal or green manure.

Chief advantages of the grasses are: (1) They can be grown

on so many soils or locations where the legumes are not suitable, (2) their length of life is indefinite whereas legumes usually disappear quickly, (3) they do not winterkill as readily as the legumes nor do they summerkill as quickly as the true clovers with extreme heat and drouth, and (4) they control erosion more effectively than the legumes. The grasses are useful for mixing with legumes on the borderline soils that produce clovers or alfalfa only fairly well and where legumes may not always be successful. Legumes also can be used with greater safety as pasture for cattle and sheep when grasses are mixed with them.

CHOICE OF LEGUMES FOR HAY

Main points considered in choosing a legume for hay are (1) soil adaptation, (2) yield, (3) quality and feeding value of the hay, (4) cost of seed, (5) life of the field, (6) time of hay making and (7) ease of handling the hay crop.

Legume hays of similar quality do not vary greatly in their feeding value. While feeding tests and analyses show considerable advantage of alfalfa over clover, pound for pound, it is believed that this advantage lies mostly in the relative time of harvesting. Alfalfa is usually cut early, in the one-tenth bloom stage, while red clover is generally cut when it is much more advanced. Red clover cut early, when the first and second crops are in the full bloom stage, is higher in feeding value and probably yields more as a total for the season than when cut later.

Alfalfa is unsurpassed for hay in yield and economy of production when soil conditions are satisfactory, and as ordinarily harvested it is higher in feeding value than any other hay. Alfalfa hay can be produced most economically if crops are harvested through 3 or more years, as long as good stands are maintained, and it can be used to replace clover in the 3 or 4-year corn, small grain and legume rotation. As a one year crop its distinct advantage over red clover is that on sweet soils stands can be obtained with greater certainty. Except on hilly land, a short rotation with alfalfa harvested for only 2 or 3 crop years is recommended to avoid alfalfa diseases and to increase its usefulness for soil improvement.

Fig. 2. A good field of medium red clover. This clover is the best general purpose hay and pasture legume for Iowa because of its wide soil adaptation and high yields. It may be grown on soils too acid for alfalfa or sweet clover, but a better growth results on such soils if the acidity is corrected by liming.

Medium red clover is the leading hay legume in Iowa primarily because it combines wide soil adaptation with high production of quality hay. Since it withstands somewhat acid soils red clover grows extensively in southern and northeastern Iowa where it is necessary to apply lime before alfalfa can be grown. Another reason for its general popularity is that it is an excellent companion crop for timothy and in a mixture with timothy can be used to advantage for those soils too acid to produce satisfactory crops of red clover when grown alone.

Mammoth red clover is grown but little, as medium red is greatly superior; the medium makes a larger growth the seeding year, finer growth the second year, yields somewhat more as a total for the season, and develops second and even third crops the second year as compared with only one crop, or at best an additional small second crop, of the mammoth.

While **alsike clover** yields much less the seeding and crop years than medium red and produces only a small second crop, if any, it is grown extensively, largely with timothy, on acid and poorly drained soils where red clover is not adapted. For such conditions alsike can be used in place of the medium red. Also, it is advisable to mix some alsike clover seed with the

medium red for borderline soils on which the medium red may fail.

Sweet clover is not recommended for hay except for cutting in late September or early October of the year it is seeded. At this time it makes excellent hay, nearly equal to alfalfa in feeding value except for the small grain stubble which it may contain. At the Iowa Station biennial white sweet clover cut Oct. 1 has produced more than a ton of dry hay per acre in an average season. In the second year sweet clover is difficult to cure, is stemmy, is apt to be killed unless cut early and high, and sometimes stock is poisoned when fed an exclusive ration of sweet clover which has molded during curing or in storage. The writers know of no case of poisoning from feeding sweet clover harvested in the fall of the first year.

Hubam clover is not recommended for hay because it becomes stemmy relatively early. It is frequently used for hay, however, and has not been known to cause poisoning, possibly because it is cut when partly in flower when molds are not as likely to develop as when sweet clover is cut when younger and more succulent.

An annual, **Korean lespedeza,** when of sufficient growth for cutting, makes excellent hay, comparable to other legume hays in feeding value. It is recommended only for the extremely acid soils of the south one-third of Iowa. In the moderately acid soils of southern Iowa medium red and alsike clovers yield much more hay.

COMPARATIVE YIELDS OF LEGUMES CUT FOR HAY

Alfalfa, medium red, mammoth red, alsike, biennial white sweet and biennial yellow sweet clovers were compared at the

TABLE 1—TOTAL SEASONAL YIELDS OF BIENNIAL AND PERENNIAL LEGUMES THE YEAR AFTER SOWING IN TONS OF DRY HAY PER ACRE

Kind	1916	1918	1922	1923	1924	1925	1927	1928	1929	Av.* 1918 1929	Av. 1927 1929
Alfalfa	1.92	2.23	1.56	4.82	4.24	3.35	3.76	3.25	4.32	3.44	3.78
Medium red clover	2.50	1.98	2.04	2.26	4.28	1.71	3.77	2.70	4.81	2.94	3.76
Mammoth red clover	2.76	2.32	3.37	2.10	3.57	1.88	3.70	1.17	3.27	2.67	2.71
Alsike clover	2.89	0.73	1.39	1.24	2.18	1.21	2.75	1.06	2.70	1.66	2.17
Bi. white sweet clover	0.87	1.47	2.18	4.42	1.47	2.55	2.70	2.58	3.54	2.61	2.94
Bi. yellow sweet clover	1.01	1.60	1.66	2.52	1.76	1.71	2.06	1.90	1.83	1.88	1.93

*Yields for 1916 are omitted from the averages because weights of one crop only were obtained in that year. Other crops were harvested in that year but yields were not taken.

Iowa Station for forage yield the second year of growth for nine years between 1916 and 1929, inclusive. The yields obtained by years, together with averages, are shown in table 1.

As an average for the period, 1918-29, alfalfa yielded 3.44 tons of dry hay per acre, medium red clover 2.94 tons, mammoth red 2.67 tons, alsike 1.66 tons, biennial white sweet 2.61 tons and biennial yellow sweet clover 1.88 tons.

While popular opinion places alfalfa much superior to medium red clover in hay yield, as a matter of fact, the yield of the two appears to be fairly similar the first crop year. The advantage of alfalfa is in the second crop year and later when it yields appreciably more than it does in the first crop year. This is because of its more extensive root system than that of the clover.

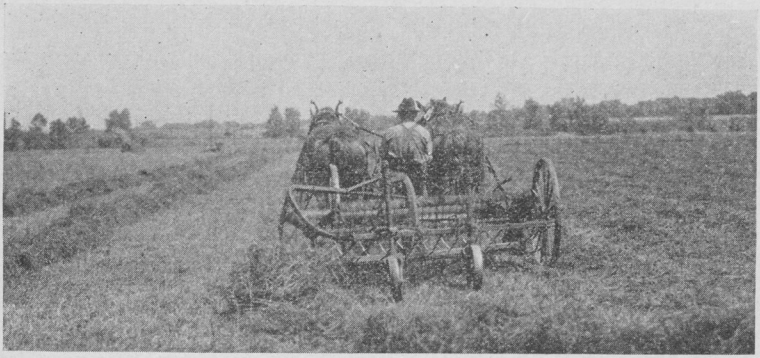

Fig. 3. A good field of alfalfa. Alfalfa is unsurpassed for high yields of hay of the best quality when grown on reasonably fertile, well drained soils, plentifully supplied with lime.

To present a more comprehensive picture of the true yielding ability of the six legumes, the aftermath growth was harvested from 1927-29, inclusive, and included in the total yields. The aftermath growth included second crops of mammoth and alsike, the third of medium red and the fourth of alfalfa. If the alfalfa field is to be continued, the fourth crop, of course, should not be harvested. With the aftermath crops included in the yields for 1927-29, inclusive, alfalfa yielded 3.78 tons of hay, medium red clover practically the same, or 3.76 tons, mammoth red 2.71 tons, alsike 2.17 tons, biennial white sweet 2.94 tons and biennial yellow sweet clover 1.93 tons per acre.

Hay crops of the sweet clovers as ordinarly harvested do not give their true yielding ability because these clovers are given a severe setback by removal of the first crop unless cut in the bud stage—about 14 inches high—with the grain binder, since all growth must come from the stems. In the Iowa tests the first crop was removed when in the bud stage, with the mower equipped with homemade shoe and wheel to cut 9 inches high. Most of the sweet clover usually continued to grow, but growth was spotted and recovery slow.

While Iowa farmers generally prefer not to allow biennial sweet clover to reach the full bloom stage before cutting for hay, yields taken at that time give a better idea of the true yielding ability of the clover. As an average for 1927 and 1933 at the Iowa Station common biennial yellow sweet clover cut

TABLE 2—YIELDS OF BIENNIAL SWEET CLOVERS, CUT ONCE IN THE FULL BLOOM STAGE. IN TONS OF DRY FORAGE PER ACRE

Kind of sweet clover	1927	1933	Av.
Common yellow	3.34	3.41	3.38
Grundy County white	3.03	2.90	2.97
Common white	4.39	4.69	4.54
Iowa Late white	....	5.44	....

once in the full bloom stage yielded 3.38 tons of dry hay per acre, Grundy County biennial white 2.97 tons, and common biennial white 4.54 tons per acre. (table 2.) In 1933 a late strain of biennial white yielded 5.44 tons of dry hay per acre, equivalent to a yield of 16 tons of green manure or silage. Seed of this strain—Iowa Late White sweet clover was distributed by the Iowa Station in the spring of 1935.

Korean lespedeza was compared with medium and mammoth red and alsike clovers on 60-bushel corn soil, well supplied with lime, in 1932. Seedings were made in April, and yields obtained in October of the same year. Medium red clover yielded 0.83 of a ton of dry hay per acre, about 50 percent more than the lespedeza, alsike or mammoth clover which yielded 0.55, 0.53 and 0.56 of a ton per acre, respectively.

This test indicates that on fertile, limed soils Korean lespedeza will not yield as much hay as medium red clover even in the fall of the first year of growth of the clover. It is a general observation, however, that the Korean makes a much better growth from a volunteer stand than when seeded on land for the first time.

When a one-half ton or perhaps larger yield of Korean lespedeza is compared with the 2.94, 2.67 and 1.66 ton yields of medium and mammoth red and alsike clovers obtained in the second year it is apparent that the lespedeza is only one-fifth to one-half as good as these clovers on fertile, limed soils.

CHOICE OF GRASSES FOR HAY

In general the choice of a grass for hay production is based on (1) its relatively high yields, (2) palatability and feeding value, (3) general suitability for sowing on a particular soil (at a reasonable cost for seed) with a clover, provided, that the clover will grow, and with the idea of (4) later converting the meadow into a pasture.

Timothy leads as a hay grass principally because of its low seed cost and ease of seeding, regularity of stands, high forage yields, wide soil adaptation and suitability for sowing with the clovers.

Reed canary is an excellent grass, particularly adapted to poorly drained areas, and also the highest yielding for a 4-year period in tests on upland, 60-bushel corn soil at Ames. This grass on upland soil, however, usually becomes "sod-bound" and less productive by the end of 5 years. The hay, while coarse and appearing harsh, is relished by stock. In 1926 reed canary grass hay, harvested 10 days after the seed was ripe, was fed the following winter to a group of brood mares and was entirely consumed before timothy, fed in comparison, was more than barely sampled. It is unfortunate that seed of this excellent grass is so expensive. This is because the seed falls out of the head as soon as ripe, and that seed yields are low after the grass becomes "sod-bound" on upland soils.

Brome is another high yielding grass in meadows, and the hay is of excellent quality. It no doubt would be a competitor of timothy if seed were available at a comparable price and if seedings could be made as easily and with the same assurance of obtaining a stand.

In certain of the poorer soils red top is better adapted than timothy, makes a fair quality of hay if cut reasonably early, and seed is usually plentiful at a moderate price. It yields less than timothy on good soils and the plants become woody and unpalatable unless cut by the time they are in full bloom.

Tall oat grass is a good hay grass and ranked with timothy and brome in yield tests at the Iowa Station. It is strictly a bunch grass, however, and does not produce a good sod. Also it is generally more difficult to get stands of tall oat grass than of timothy, and seed is expensive.

Other grasses which may be used in Iowa but generally considered to be inferior for hay are meadow fescue, orchard, slender wheat, and crested wheat. Perennial or English rye grass has always winterkilled the first winter in tests at Ames.

COMPARATIVE YIELDS OF GRASSES CUT FOR HAY

Yield comparisons were made at the Iowa Station of reed canary, timothy, brome, tall meadow oat, red top, meadow fescue and orchard grasses during the 4-year period of 1925-28, inclusive, and results are shown in table 3. When possible,

TABLE 3—YIELDS OF SEVEN COMMON GRASSES IN TONS OF DRY HAY PER ACRE AND PERCENTAGE OF REED CANARY GRASS

Kind	First Crop		Second Crop		Total	
	Average 1925-28	Percent of Reed Canary	Average 1925-27	Percent of Reed Canary	Average 1925-28	Percent of Reed Canary
Reed canary	1.51	100	0.72	100	2.06	100
Brome	1.27	84	0.24	33	1.45	70
Timothy	1.12	74	0.42	58	1.44	70
Tall oat	0.93	62	0.61	85	1.39	67
Red top	0.95	63	0.30	42	1.18	57
Meadow fescue	0.70	46	0.37	51	0.98	48
Orchard	0.56	37	0.36	50	0.83	40

two crops of each grass were harvested in each year except in 1928 when the test was discontinued after removing the first crop. As an average for the four years, total of both crops, reed canary grass yielded 2.06 tons of dry hay per acre, brome grass 1.45, timothy practically the same or 1.44, tall oat grass 1.39, red top 1.18, meadow fescue 0.98 and orchard grass 0.83. It is apparent that under these conditions reed canary was outstandingly highest while the timothy, brome, and tall oat grasses were about on a par in second position. Red top was fairly good while meadow fescue and orchard were greatly inferior to the leading four.

Yield percentages indicate that brome grass gave unusually low second-crop yields as compared with the first; otherwise the first and second-crop rankings are fairly similar except that red top also gave a comparatively low second-crop yield.

The performance of the grasses during the unusually dry

summer of 1927 is noteworthy. In that year reed canary yielded more than it did in either of the two previous, more nearly normal, years possibly because it was better established by that time. Reed canary yielded 2.99 tons per acre in 1927 as a total of two crops or nearly twice as much as the next best grass. Brome grass was second with a yield of 1.69 tons, tall oat grass third with 1.48, timothy and red top tied for fourth with 1.34 tons each, meadow fescue was sixth with 1.03 tons and orchard grass was last with a total yield of only 0.53 of a ton per acre. Reed canary, tall oat and orchard were the only ones of the seven grasses that grew second crops high enough to be cut with the mowing machine. The second crop yields of these three grasses were reed canary 0.50 ton, tall oat 0.19 and orchard 0.12 of a ton per acre.

LEGUME AND GRASS MIXTURES FOR HAY

Medium red clover and timothy, or alsike clover and timothy, or mixtures of the three are standard in Iowa. They are used principally on soils too acid or too poorly drained for safe culture of the clovers seeded alone, and the mixture may be expected to yield more than clover grown alone.

On soils that will grow the legumes it is a distinct advantage to include them with timothy or other grasses in order to increase the yield and feeding value of the grass hay. Also, it has been demonstrated in tests at the Iowa Station and elsewhere that the grasses grow best when in association with legumes.

In general, grasses for the mixture may be chosen in the order of their preference when grown alone. Seed prices and supply may determine one's choice among timothy, brome and tall oat grasses for the meadow mixture. Reed canary is sufficiently superior to warrant paying a considerable premium for seed especially when it is to be used on poorly drained soil. Red top may be used in place of the others for acid soils especially low in fertility.

Under certain conditions some grass seed may be mixed with alfalfa to advantage. The Wisconsin station for years has recommended a light mixture of timothy in alfalfa, stating that Kentucky bluegrass is held in check better by the timothy. Recently the Illinois station has found that alfalfa stands are maintained longer in bacterial wilt infected soils if

some timothy is mixed with the alfalfa seed. The Ohio station reports higher seasonal yields from the alfalfa-timothy mixture than from alfalfa alone on the marginal soils not well adapted to alfalfa because of shortage of lime, low fertility and inadequate drainage. Tests with the alfalfa-timothy mixture at the Iowa Station have not been continued long enough to justify a recommendation. It is suggested, however, that Iowa farm operators who have difficulty in growing alfalfa alone, or who desire to pasture with cattle or sheep, may well try the mixture, seeding possibly 10 pounds of alfalfa and 4 to 7 pounds of timothy per acre.

LEGUMES AND GRASSES FOR PASTURE

The legumes have the same advantages in general, over the grasses for pasture as they do for hay when considered from the standpoint of production and of feeding value. Likewise, the grasses have certain advantages over the legumes for soils low in lime, from the standpoints of length of life and of erosion protection. The grasses, also, seldom cause sheep and cattle to bloat, whereas, there is always danger of loss from bloat when these animals are pastured on clover or alfalfa solely.

Unless the pasture is to be used exclusively for hogs it is

Fig. 4. Orchard is the best grass for locations such as this which are too shady for Kentucky bluegrass or timothy. Red top is the best grass for soils too poor, too acid, or too poorly drained for Kentucky bluegrass. Brome grass is driven out by Kentucky bluegrass in pastures closely grazed and in general is inferior to Kentucky bluegrass for pasture and to timothy for hay.

usually best to seed a mixture of legumes and grasses for pasture from the standpoints of production, general cover over the average field, life of the pasture, variety of feed furnished, and curtailment of bloat among the grazing animals. It is a common experience that legumes are much less likely to cause bloat of cattle and sheep if the legume pasture contains a liberal grass mixture.

The subject of pastures may be discussed conveniently under four main headings: (1) emergency or supplementary pastures, (2) short rotation pastures, (3) long rotation or semi-permanent pastures, and (4) permanent pastures. For the first of these, the emergency or supplementary pasture, the annual crops, winter rye, winter wheat, oats, barley, sudan grass and rape, are used mainly, and such other annuals as millet and sorghum, occasionally.[5]

SHORT ROTATION PASTURES

Short rotation pastures are those for which legumes, grasses, or mixtures of the two, with possibly some rape added, are seeded in the spring with a small grain nurse crop. The nurse crop may well be pastured off if it can be so used advantageously, and followed by moderate pasturing throughout the season. Frequently the nurse crop is removed for grain or hay, however, and pasturing begun after the legume or mixture has made sufficient growth following harvest to have established itself. Usually such pastures are carried over and pastured the second year since they yield much more the second season than the first. Plowing in preparation for corn generally follows the first or second pasturing season.

Short rotation pastures may be expected to supply a large amount of forage at moderate cost. They are particularly valuable when pastured throughout the first season, beginning as soon as the nurse crop is 7-8 inches high, and continuing through the second season.

Biennial sweet clover is by far the most valuable legume for the short rotation pasture on limed soils since it outyields any of the others in both the first and the second years. With its general use in Iowa some reaction against it has developed in certain communities, however, because of danger from bloat

[5] A discussion of the annual forage grasses and rape, when seeded alone, is outside the scope of this publication.

of cattle and sheep. This has been investigated by the Iowa Station in extensive interviews with farmers. While to date no absolute bloat preventive has been discovered, those who are following a few simple precautions apparently have but little trouble.

REDUCING DANGER OF BLOAT

Bloating of stock pasturing sweet clover is confined almost entirely to May and early June of the second year when the forage is green and succulent. Very little trouble is experienced in the fall of the first year, or after the clover is in flower the second year.

Bloating is often confined to three or four animals in the herd and if these are limited to a grass pasture the difficulty is sometimes entirely eliminated. Also, pasturing should not be begun when the animals are hungry or when the sweet clover is damp with rain or dew. Once pasturing is started it is best to leave the animals in the pasture all of the time. Fresh water should be available at all times, preferably in the pasture. If this is not possible the stock may well be driven to water at least four times daily, as they are apt to become too thirsty before leaving the pasture voluntarily. It is advisable also to feed straw or hay while pasturing sweet clover, since the animals crave the dry feed and are not as likely to eat too much clover. Timothy or other grass seeded liberally with sweet clover gives a change of diet relished by the animals, and apparently is particularly valuable in preventing bloating. Some stockmen accomplish the same end by having a grass pasture next to the sweet clover so that animals can graze from one pasture to the other at will. Also, the animals should have access to liberal quantities of salt and other minerals. A standard mineral mixture, recommended by the Animal Husbandry Section of the Iowa Station, consists of 20 pounds of salt, 40 pounds of finely ground limestone, and 40 pounds of bonemeal to which may be added one-half ounce of potassium iodide per 100 pounds of the mixture. Mixing slacked lime with the drinking water does not prevent bloat; but many farmers believe that it is helpful.

A preventive measure to avoid bloat, practiced on some farms, is to begin pasturing early when the sweet clover is about 4 inches high, and when it is necessary to supplement the sweet clover pasture with other feed. Following this the

pasture is so heavily grazed that it is necessary to continue supplementary feeding. This plan is not recommended because the sweet clover may yield the most when it is allowed to maintain a growth of a foot or more. It is far better, however, than not using second-year sweet clover for pasture at all.

OTHER SHORT ROTATION PASTURES

Legumes, besides sweet clover, that may be used in the short rotation pasture in their order of production are alfalfa and medium red, mammoth red and alsike clovers and Korean lespedeza. Alfalfa and the clovers, when grown without grasses and when an abundance of pasturage is available to stock, are probably just as apt to cause bloat as sweet clover. When liberal mixtures of grasses are included, however, not much trouble is generally experienced. Alfalfa, with perhaps a worse reputation for causing bloat of cattle and sheep when grown alone than sweet clover, is a favorite ingredient in legume and grass mixtures in certain sections of Iowa.

Upon soil acidity largely depends the choice of legumes for the short rotation mixture and since more than 75 percent of Iowa soils are acid this is an important consideration. On soils known to be sweet over the entire field, as is generally the case along the Missouri river, the mixture may well consist largely of sweet clover with enough medium red clover and timothy added to give plenty of variety, and also that the pasture may be used until August of the second year. By that time the new seeding should be far enough along to pasture.

On soils known to be sweet in parts of the field and sour in others—a typical condition in northwestern Iowa—it is advisable to reduce the amount of sweet clover seed in the mixture, increase the medium red, and also add some alsike, thus having a mixture consisting of sweet clover, medium red and alsike clovers and timothy. If the percentage of sweet soil in the field is small the sweet clover amount may well be reduced to near the vanishing point.

On soils known to be acid over the entire field, as is rather general in northeastern and southern Iowa, the sweet clover should be omitted entirely and the proportion of alsike clover increased appreciably. The mixture on such soils, thus would consist of medium red and alsike clovers and timothy. With increasing acidity or poor drainage the alsike clover and tim-

othy can be increased with the medium red clover decreased. In the most acid soils of southern Iowa Korean lespedeza can be used to advantage in place of the medium red clover. Lespedeza can be grown in all parts of Iowa but does not mature seed consistently or make much growth north of the south one-third of the state. Since it is an annual and dies at the end of the first season, the crop the next season must volunteer from seed which ripened on the crop of the previous year, unless it is reseeded.

If the farm operator sows a mixture of sweet clover, medium red and alsike clovers, Korean lespedeza and timothy he can readily determine for himself which of these kinds grows the best on the particular field on which they are tried. This will serve as a guide in making up mixtures for future seedings.

Experiments at the Iowa Station and observations on Iowa farms indicate that rape may well be included in the short rotation pasture mixture, except when the pasture is to be used for dairy cows. Since rape grows well in acid soils it is particularly valuable for soils too acid for sweet clover. Even when sweet clover is used, pasture yields the first season are likely to be increased by the addition of rape. Apparently on fertile soils it gives higher yields following the removal of the small grain nurse crop than any of the legumes with the possible exception of sweet clover. Rape in the mixture is particularly valuable when the pasture is to be used throughout the season from the time the nurse crop is 7-8 inches high, as the rape comes on more vigorously and more rapidly than the clovers and helps to hold up the pasture about the time the small grain is gone and the clovers are not yet well established. If too much seed is included in the mixture, however, the rape greatly weakens the legumes and grasses. Apparently not over 1½ pounds of rape seed per acre should be included in the legume grass mixture.

Other grasses, of course, can be added to the timothy-legume mixture or substituted entirely for the timothy. Cost of seed, however, is one of the chief factors to consider in the short rotation pasture and usually timothy will have first choice. Red top is preferable to timothy for the poorest, acid soils and those that are poorly drained. Tall oat is a bunch grass and does not withstand pasturing well. Orchard is also a bunch

grass but withstands pasturing, grows well in the shade of sweet clover and should do well in the second year for those who do not keep the sweet clover grazed closely to the ground.

COMPARATIVE YIELDS OF SHORT ROTATION PASTURE MIXTURES

In 1932 and 1933 different combinations of clovers, alfalfa, rape and timothy were seeded with different nurse crops, on fairly fertile, limed soils, and yields were obtained in a way to approximate the yields that would have been obtained had the nurse crops and the mixtures actually been pastured the seedling year. The seedings were plowed up at the end of the first year. Yields of dry forage obtained for the different mixtures, together with the total seasonal yield, and with that of the best nurse crop included, are given in table 4. Yields of both nurse crops and mixtures were low in 1933 because of the drouth and their location on a gravelly soil.

TABLE 4—YIELDS OF DRY FORAGE OBTAINED WITH DIFFERENT PASTURE MIXTURE COMBINATIONS OF CLOVERS, ALFALFA, RAPE AND TIMOTHY SEEDED WITH OATS AND HARVESTED IN OCTOBER OF THE YEAR OF SEEDING

Ingredients and rates of seeding in pounds per acre	Tons per acre			
	Year seeded and harvested		Average	Average (Nurse crop included)
	1932	1933		
White sweet 7, medium red 2, alsike 1, timothy 4	1.16	0.95	1.06	1.90
White sweet 4, medium red 4, alsike 2, timothy 4	0.85	0.78	0.82	1.66
White sweet 2, medium red 6, alsike 2, timothy 4	0.62	0.50	0.56	1.40
Medium red 8, alsike 2, timothy 4	0.38	0.19	0.29	1.13
White sweet 4, medium red 4, alsike 1, timothy 4, rape 3	1.07*	1.38†	1.23‡	2.07
Alfalfa 7, medium red 2, alsike 1, timothy 4	0.43	0.48	0.46	1.30

* 52% rape. † 65% rape. ‡ 58% rape.

The results show definitely that on limed soils a mixture containing a large amount of sweet clover may be expected to give high yields. As the amount of sweet clover is reduced with medium red, and alsike clovers increased, the yields are lowered. They indicate also that rape is an excellent ingredient to include, particularly on fertile soils where acidity prevents the growing of sweet clover. They show that alfalfa is

Fig. 6. A biennial white sweet clover pasture on the College Dairy Farm. This clover provides a large amount of excellent pasture during both the first and second year of growth. On page 107 are given the suggestions of stockmen for minimizing dangers from bloat. This second-year sweet clover is being pastured at about the right height.

not nearly as productive in the first year pasture as sweet clover and that a mixture made up of medium red and alsike clovers and timothy with no sweet clover, alfalfa or rape included is the least productive of all. Timothy did not enter into these yields appreciably, and if the pasture is intended for one year only, the timothy may be omitted. It should be emphasized that the chief value of alsike clover and timothy comes in the second year. Sweet clover for sweet soils and rape for both sweet and sour soils are the most productive ingredients for pasture the first year.

As an average for both years the highest yield was obtained from seeding 4 pounds of common white sweet clover seed, 4 of medium red, 1 of alsike, 4 of timothy and 3 pounds of rape per acre (table 4). This mixture gave a yield of 1.23 tons per acre, containing 58 percent rape and the rest mainly sweet clover. The total yield with the nurse crop included was 2.07 tons per acre. In 1933 the rape appeared to be entirely too thick and apparently had weakened the clover. This is an important consideration when the seeding is to be left for the second year. Apparently 1½ pounds of rape per acre instead of 3 would have been better.

The second highest yield as an average for both years was obtained with a mixture of 7 pounds of white sweet clover seed, 2 of medium red, 1 of alsike and 4 pounds of timothy per acre.

This mixture gave an average yield of 1.06 tons, mostly sweet clover, and with the addition of the oat nurse crop a total yield of 1.90 tons per acre of dry forage for the season. These yields are only slightly lower than those obtained from the mixture containing the same four ingredients plus rape.

The lowest yielding mixture, with seed for an acre made up of 8 pounds of medium red clover, 2 of alsike and 4 of timothy, produced 0.29 of a ton per acre. With some reduction in the amounts of medium red and alsike seed, sweet clover seed, in increasing amounts, raised the yield to 0.56, 0.82 and 1.06 tons per acre. The total seasonal yields, including the nurse crop, ranged from 1.13 tons per acre of dry forage for the medium red-alsike-timothy mixture to 2.07 for the white sweet-medium red-alsike-timothy-rape mixture.

NURSE CROPS FOR PASTURE MIXTURES

The nurse crops used for seeding with the pasture mixtures included Green Russian oats at both 2 and 4 bushels per acre, Iowa 105 oats at both 2 and 4 bushels per acre, and Spartan barley, Early Java spring wheat and Ioturk winter wheat each at 2 bushels per acre. Yields are shown in table 5.

TABLE 5—YIELDS OF DRY FORAGE OBTAINED FOR DIFFERENT NURSE CROPS SEEDED WITH THE PASTURE MIXTURES INDICATED IN TABLE 4

	Rate Seeded (bu. per A.)	Tons per acre		
		1932	1933	Av.
Green Russian oats	2	1.17	0.50	0.84
Green Russian oats	4	1.13	0.54	0.84
Iowa 105 oats	2	0.93	0.45	0.69
Iowa 105 oats	4	0.88	0.55	0.72
Spartan barley	2	0.61	0.74	0.68
Early Java spring wheat	2	0.92	0.29	0.61
Ioturk winter wheat	2	0.31	0.12	0.22

Considering both yield of the nurse crop and effect upon the mixtures, Green Russian oats at 2 bushels per acre gave the best results. Differences were not outstanding, however, except that Green Russian at the 4-bushel rate was too thick for best stand and growth development of the mixtures, and spring sown winter wheat, while an excellent nurse crop, made comparatively little growth.

Green Russian, a medium late oat, is a poor nurse crop when harvested for grain. When pastured or cut early, as it was in this experiment, however, it is satisfactory as a nurse crop, yields more forage than the early varieties, and extends the

pasturing season several days. The 2-bushel rate of seeding the late oats is superior to the 4-bushel rate not only as a nurse crop but also because with the thinner seeding the oat plants are given more of an opportunity to stool. The younger shoots which develop further extend the pasturing period.

Iowa 105 oats were about equal to Spartan barley. They gave similar yields of forage and reacted fairly similarly upon the stand and growth of the mixtures. Both yielded about 17 percent less forage than the later Green Russian oats. When cut for grain Iowa 105 is the best of the oat nurse crops, while Spartan is one of the best of the barleys. Both are among the best of nurse crops.

Winter wheat, when spring sown, does not head but develops many basal leaves about like it does in the fall. It appears to be one of the best nurse crops when the grower is interested primarily in the stand and growth of clovers seeded with it. Yield of the winter wheat nurse crop as shown is somewhat misleading in that, as harvested, much of the spreading, leafy growth of this grain was not obtained for weighing. Apparently the growth is too small, however, for winter wheat to compete with oats to furnish spring pasture. Animals would eat these leaves borne close to the ground so that actual pasturing tests probably would give results more favorable to the winter wheat. In tests at the Iowa Station the spring-sown winter wheat has sometimes persisted far into the summer, long after oats were gone. Further experimentation with the short rotation pastures is needed.

On many farms and under many conditions the best nurse crop that can be used for the short rotation pasture, when the small grain is pastured off beginning in early spring, is winter rye or winter wheat, fall sown. They may be expected to supply more pasture than spring sown grain and are available much earlier in the season. Both winter rye and winter wheat, fall sown, are poor nurse crops, when harvested for grain, especially on fertile soils, because of the dense smothering effect on the clover seedlings. When these nurse crops are pastured off, however, the pasture mixtures are given an opportunity to grow. When winter rye or winter wheat, fall sown, are used, the pasture mixture may best be broadcast about March 15 to 25 when no covering is necessary. It is important to have

the mixtures start to grow as early as possible and to put on sufficient stock to keep the small grain pastured down fairly short.

LONG ROTATION OR SEMI-PERMANENT PASTURES

The long rotation or semi-permanent pastures are begun as meadows or short rotation pastures and pastured for perhaps several years before the land is replowed and again planted to corn. All that is necessary, therefore, in establishing these pastures is to plan in advance and include seed of pasture grasses in the legume-grass mixture.

The most important ingredient to add to the short rotation pasture mixture to make it suitable as a mixture for the permanent pasture is Kentucky bluegrass. Tests at the Iowa Station show conclusively that it may take years for Kentucky bluegrass to form a sod when seed is not included in the mixture and the bluegrass is simply allowed to volunteer. These tests show also that if as little as 3 pounds of Kentucky bluegrass seed per acre are included in the seeding mixture on fertile soils a good sod may be expected in 3 or 4 years. More

Fig. 7. In a southern Iowa Kentucky bluegrass pasture. In general the grasses are less exacting in their lime and drainage requirements than the legumes. This is the best pasture grass for general use in Iowa in spite of its low production in midsummer. The Kentucky bluegrass has effectively checked gully and sheet erosion in this field. Three to seven pounds of bluegrass seed per acre should be added to the timothy-clover mixture intended for semi-permanent pasture.

seed, of course, will establish the grass sod more quickly. The Iowa Station tests indicate also that under pasture conditions, Kentucky bluegrass if included in the mixture will crowd out practically all other grasses in a comparatively short time.

In 1928 various mixtures of grasses and legumes were seeded for pasture comparisons. Two hay crops were removed in 1929 and the fields pastured since that time. In these mixtures Kentucky bluegrass was seeded in competition with timothy, brome, red top, orchard, reed canary, Canada blue, tall oat, meadow fescue, sheep's fescue, slender wheat, crested wheat, rough-stalked meadow, crested dog's-tail, sweet vernal and perennial rye grasses. Six years after seeding, Kentucky bluegrass has practically exterminated all of the grasses in plats where it was included in the seeding mixture. The only grasses not eliminated entirely are brome, orchard, reed canary, timothy and red top. It is probable that in 2 more years most of these will be crowded out. On the other hand, it seems to be important to include bluegrass in the seeding mixture if a bluegrass sod is desired rather than to expect it to come in voluntarily. Timothy-clover seedings made in 1928 and pastured each season since the spring of 1930, contained only a small percentage of bluegrass in the fall of 1934.

While these tests show definitely that none of these other grasses can compete with Kentucky bluegrass on fertile pastures when this grass is included in the seeding mixture, other tests will be required to establish the relative merits of the different grasses for pasture. In other words, it is possible that a pure stand of some other grass may yield more pasture than a pure stand of Kentucky bluegrass on an average Iowa soil.

Reed canary in pure seedings appears to be a good pasture grass on the fertile, upland soils used for the Iowa Experiment Station tests, and may yield more pasturage than Kentucky bluegrass for a few years until it becomes "sod-bound." It is doubtful if it would be as good on infertile, upland soils. In pure seedings brome grass may be better than Kentucky bluegrass, particularly in northwestern Iowa. It is not likely that red top would be better than Kentucky bluegrass except on some of the most infertile soils or under poor drainage conditions.

Iowa Station tests show that Kentucky bluegrass provides a much better sod than any of the other grasses. This is a distinct advantage on hilly land, subject to erosion. Tests show also that Kentucky bluegrass may be expected to withstand close grazing better than any of the other grasses.

Legumes included in the seeding mixture largely disappear by the end of the second year and do not reappear in quantity unless reseeded. Exceptions to this are noted in an occasional pasture where sweet clover is allowed to set and shatter a seed crop. Some of this seed is hard, and a little of it germinates each year over a period of 15 and more years. Also, if the volunteer plants are given an opportunity to set some seed the continuous volunteering is favored.

White clover also comes and goes in pastures, in some more than others, depending upon soil and moisture conditions. While this legume is a perennial it is killed by dry, hot weather, probably hastened by over-grazing. Supposedly it continues to volunteer from hard seed which set with favorable conditions and seasons. Although white clover makes comparatively little growth it is highly desirable to have it in a pasture, not only because of the feed value but because it stimulates the growth of the grasses. It is advisable, therefore, to include some white clover seed in the semi-permanent pasture mixture.

Alfalfa is a long-lived perennial under favorable climatic conditions, but the conditions for its long life are not favorable in Iowa, and particularly unfavorable in a grass pasture. Alfalfa does live longer in a pasture, however, than red and alsike clovers, when not too closely grazed, and a little alfalfa seed may well be included in the semi-permanent pasture mixture. Conditions for seed setting of alfalfa are not favorable in Iowa, and it cannot be expected to volunteer as do the sweet and white clovers.

Medium red and alsike clovers, ordinarily thought of as biennials are really perennials but do not persist as long as alfalfa. At the Iowa Station they have usually lived through the second winter, disappearing by the end of the third summer or the third winter. Even though they do not live long they usually are basic ingredients of the semi-permanent pasture mixture. They may well be included because of the large amount of pasture they supply during the first two years, and

sometimes the third, and because of the stimulus they give to the grasses. They volunteer comparatively little in a pasture.

Korean lespedeza may be included to advantage in the semi-permanent pasture mixture in the south one-third of Iowa because these soils are generally too acid for the best growth of the clovers. Like most of the other legumes lespedeza does not maintain itself in a good sod of Kentucky bluegrass.

Since the legumes generally disappear by the third or fourth year it is sometimes desirable to reseed them. This is particularly advantageous on the poorer soils where the grass stand is not heavy. It probably is not profitable for fertile bluegrass pastures that are heavily sodded. The lime requirements of the soil should be studied carefully before blending the reseeding mixture, and it is often advisable to broadcast lime on the pasture, working it into the soil with the seed by discing. It is preferable to do the liming a year before reseeding.

Alfalfa for Pasture

The pure alfalfa hog pasture, perhaps with a little timothy mixed with it, is a distinct type of long-rotation pasture. It has proved itself in many experiment station tests to be superior to any other kind of pasture for hogs. Length of life of the alfalfa pasture depends largely upon the way it is handled and soil freedom from disease. If it is to have a comparatively long life it should be lightly grazed, particularly in late August and September. A good guide is to pasture lightly enough so that occasional shoots are allowed to flower. An alfalfa pasture so managed should last through 3 to 4 years, not counting the seedling year when it is best not to pasture it at all.

The Michigan station highly recommends alfalfa as pasture for cattle and sheep, stating that it is more productive than second-year sweet clover, and no more likely to cause bloat. It is advisable to mix timothy or other grass with alfalfa when the legume is to be used for cattle or sheep pasture.

Kentucky bluegrass slowly works its way into the alfalfa pasture, and bluegrass pastures established this way are among the best. As the alfalfa plants gradually die off they furnish the bluegrass with an abundance of nitrogen and other available nutrients. A pronounced stimulus, thus, is given to the grass growth. Because of the fertilizing value of the alfalfa,

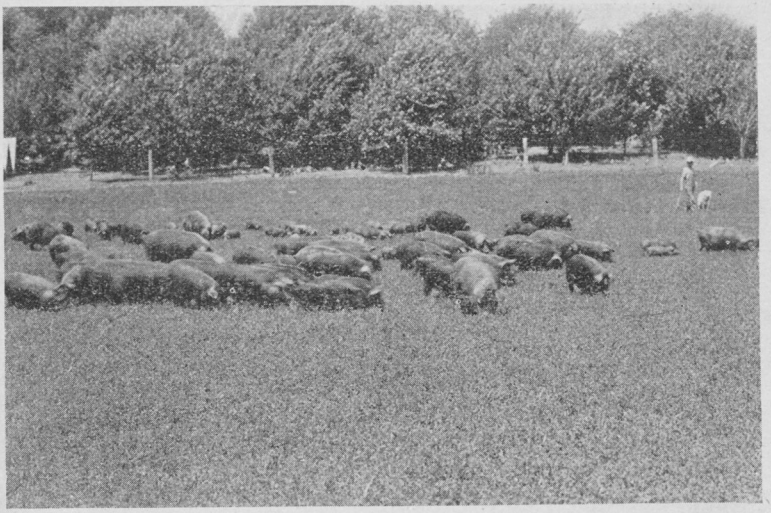

Fig. 5. Alfalfa is best of all crops for hog pasture. In some states it is highly recommended as cattle pasture also where it is said that it does not cause more bloat than sweet clover. The danger from bloat is lessened by mixing timothy with it.

Kentucky bluegrass volunteers much more quickly and sods more rapidly in an alfalfa field than it does in a timothy or other grass pasture or meadow.

PERMANENT PASTURES

Permanent pastures are those that are never plowed, usually because of topography or obstructions. Practically all of these in Iowa are maintaining poor to good stands of Kentucky bluegrass depending upon the type and natural fertility of the soil and pasture management. Permanent pastures are occasionally found where the soil is too infertile, too acid, or too poorly drained for Kentucky bluegrass; under such conditions redtop is likely to predominate. Canada bluegrass is also found to some extent in the state on the higher, drier, less fertile soils, this grass often replacing Kentucky bluegrass as soils lose their fertility, either from erosion or leaching, or excessively close grazing with nothing returned to the soil.

Practically all that has been said of the choice and adaptation of grasses and legumes under the discussion of semi-permanent pastures applies to permanent pastures.

On the more fertile soils Kentucky bluegrass will crowd out any other grass which may be seeded with it or in it. On the

more worn and infertile soils, however, Kentucky bluegrass often becomes unproductive making some reseeding desirable. For this purpose the legumes should be used in order to build up and increase the productivity of the soil. Sweet clover, alfalfa, red clover, alsike clover and Korean lespedeza have the greatest value depending upon location and soil acidity. If the soil is sweet, sweet clover and alfalfa may well be used in preference to anything else, while on most southern Iowa soils, if the reseeding is done without liming, a mixture of red clover and alsike clover, with lespedeza in the southern two or three tiers of counties, will be found more satisfactory.

LEGUMES FOR GREEN MANURE

Because the more important soil constituents, nitrogen and organic matter, are most readily lost, nearly all soils can be improved by growing legumes. They may either be plowed under as green manure or fed to livestock and the manure applied on the land. Increase in yields obtained from the use of green manure depends largely upon the fertility of the soil. On 50 to 60-bushel corn soil at the Iowa Station increases in yields of corn and small grain resulting from the plowing under of leguminous green manure crops have been about 10 to 20 percent. On the other hand, operators farming 30 to 40-bushel corn land frequently report increases in yield of as much as 30 percent, or more, from growing sweet clover in oats and plowing the legume under in preparation for corn the next year. To obtain these increases, however, it is necessary to have a soil well supplied with phosphorous, potassium, and calcium.

Inoculated legumes, in general, are valuable to the soil in proportion to the amount returned to the land, either directly as green manure, or indirectly as animal manure. When the crop is cut close to the ground and sold off the farm the soil is not benefitted appreciably. On the other hand, when most of the top growth is plowed under, or when the product is fed and returned to the land in the form of animal manure, the soil is enriched in nitrogen and organic matter accordingly.

Soil fertility can be decreased with a legume crop the same as it can with grain or corn unless a large part of the plant growth is returned directly or indirectly to the land. This

fact influences the choice of legumes for soil improvement as well as the method of handling them. Inoculated legumes take part of the nitrogen for their growth from the air. The percentage of nitrogen that comes from the air depends largely upon fertility of the soil. More of it comes from the air when the legumes are grown on soils low in nitrogen than when they are grown on soils high in nitrogen. All of the other nutrients besides nitrogen must come from the soil. Choosing a legume for soil improvement with the purpose of returning as much as possible of the growth to the soil, either as green or as animal manure, therefore, is exceedingly important and cannot be over emphasized.

Fig. 8. Plowing under a growth of biennial sweet clover in the late fall of the first year. On 50 to 60-bushel corn soils sweet clover has increased the yield of corn an average of 17 percent and of oats 18 percent at the Iowa Station in a two-year rotation of corn and oats with sweet clover seeded in the oats and plowed down for corn the following spring. Greater increases are obtained on less fertile soils. A crop such as this, harvested about Oct. 1, will yield more than a ton of good hay per acre, or it may be pastured off to excellent advantage.

Extent of root growth must be considered carefully, also, when weighing the relative soil improvement merits of different legumes. The biennial and perennial legumes have a large part of their weight in the roots, since food is stored there for growth the next year. Annual legumes, because they die as soon as they form seed, do not store much food in the roots, and the roots of these plants comprise a comparatively small part of their total growth. It is apparent, therefore, that if the top growth of biennial or perennial legumes is removed

and sold off the farm, considerable root growth and aftermath remain to be incorporated with the soil. On the other hand, when annual legumes are handled in a similar manner the amount of material returned to the soil in stubble and roots is small. Furthermore, annual legumes like dalea, hubam clover and soybeans die as soon as they are cut at mower height and no aftermath develops, while perennial legumes such as the true clovers and alfalfa keep on growing until late fall. It is apparent, therefore, that if annual legumes are used for soil improvement more top growth must be returned to the soil, as green or animal manure, than when perennial legumes are used in order to make up for the difference in root and aftermath growth.

Legumes suitable for green manure in Iowa include the biennial sweet clovers, hubam clover, red clover, and alsike clover, alfalfa, Korean lespedeza, dalea and soybeans.

SWEET CLOVER AS GREEN MANURE

Keeping in mind the soil adaptation of the different legumes given on pages 91 to 95 biennial sweet clover is outstanding as a green manure crop. It produces more top growth and also more root growth than any other legume available. In an average season at the Iowa Station it has yielded 3½ tons per acre of highly nitrogenous dry matter, as a total of tops and roots (considering the roots to a depth of only 10 inches), from the time it was seeded with oats until it was plowed under for corn the next year. This is equivalent to a yield of 11 tons per acre of green manure, a remarkable production when it is considered that the clover spent 3 months of this time becoming established in the oat nurse crop. Perhaps it can be visualized best by comparing it with corn, one of the most efficient of field crops, since it requires a good field of corn to yield 11 tons of silage per acre.

A considerable percentage of the biennial sweet clover plants are not killed by ordinary methods when plowed in the late fall after the clover has practically completed its growth for the season. About 20 plants per square yard, enough for a full stand of sweet clover, allowed to develop a seed crop, volunteer the following spring, and require considerable work and expense to subdue them in preparation for a corn crop.

Considering cost of fitting the seedbed, also total nitrogen and organic matter incorporated with the soil, it is better to plow the biennial sweet clover in preparation for corn in late April or about the first of May. It is known, however, that many Iowa soils are difficult to plow in the spring in time to prepare a good seedbed for corn. Also, from the standpoint of labor distribution, Iowa farmers generally prefer to do as much fall plowing as possible. Corn yields, furthermore, are likely to be higher following the fall plowing of sweet clover than when the legume is plowed under in the spring.

The Farm Crops Subsection and the Agricultural Engineering Section of the Iowa Agricultural Experiment Station, working cooperatively, are carrying on investigations on the problems of killing fall-plowed biennial sweet clover in preparation for corn.[5] In 1933 heavy crops of first year biennial sweet clover were killed practically 100 percent with a knife attachment for the plow when the sweet clover was plowed in November. The knife, attached to the land side of the plow, cuts off the sweet clover roots an inch below the crowns, and

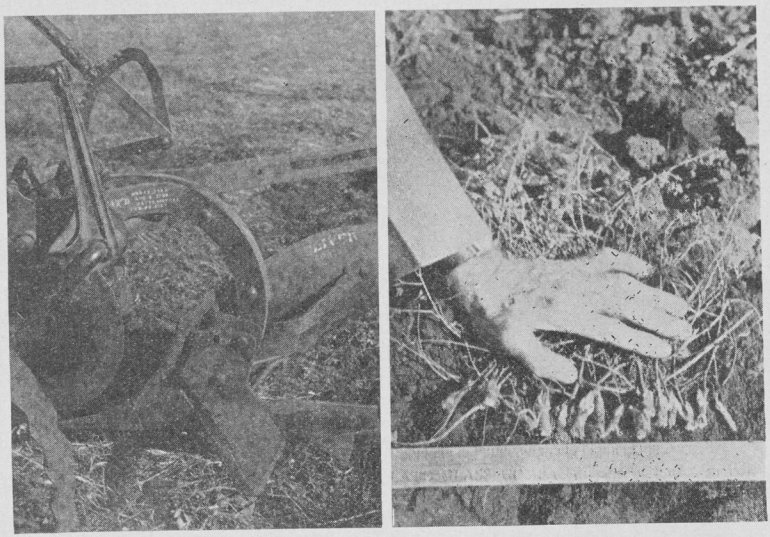

Fig. 10. When biennial sweet clover is plowed in the fall after it makes its full growth much of it is not killed. This plow is equipped with a knife on the land side. The knife cuts off the roots an inch below the crown as shown on the right. Practically all of the plants are killed when the plow is equipped in this way.

[5] The first parts of the work were reported in Research Bulletin No. 162, of the Iowa Agricultural Experiment Station.

the plow covers the tops in the bottom of the furrow the next round.[6]

Because hubam clover dies naturally at the end of the first season, and most farmers prefer to fall-plow for corn, hubam has become an important green manure and seed crop in Iowa. Hubam clover ranks next to biennial sweet clover as a green manure crop to seed with oats to be plowed under for corn.

Preliminary tests of hubam clover, compared with biennial sweet clover, as reported in 1922,[7] gave results much more favorable to hubam clover than present day tests show. This no doubt was due mainly to differences in the maturity of the hubam clover used then and that being grown now. In the yield tests of 1920 and '21 a late strain of hubam that did not mature seed following oats was used. In 1921 the late strain used had only 10 percent of its seed ripe when yields were obtained October 4. Even at that time both early and late strains were available, but since then the early strain has come to be grown exclusively in Iowa. This is a logical development because economical seed production demands that the hubam clover seed crop be grown following removal of the small grain nurse crop, and the value of any sown crop depends, to a considerable extent, upon availability and low cost of its seed. Hubam clover now available ripens its seed in September, and some ripe seed is usually found in August. The growing season, hence, is shorter than that of the later strain, and the growth it makes is smaller.

The height at which the nurse crop is cut also makes a great deal of difference in the comparative growth of the hubam and the biennial sweet clovers, following small grain harvest. After being cut off, the entire new growth of both clovers comes from the stems. The new growth buds of the biennial are borne much nearer to the ground, however, than those of the hubam. Cutting the nurse crop six inches high, therefore, does not injure the biennial but it does injure the hubam greatly. Furthermore, many of the hubam plants are killed. The nurse crop with which hubam clover is seeded should be cut at least 11 inches high if possible.

[6] The knife attachment for the plow was invented by Prof. E. V. Collins of the Agricultural Engineering Section, and the writers are indebted to him for permission to reproduce the photograph in this bulletin.

[7] Circular No. 76, Iowa Agricultural Experiment Station (out of print).

OTHER GREEN MANURE LEGUMES

Medium red clover, mammoth red clover, alsike clover and alfalfa may be used for green manure as biennial sweet and hubam clovers are used, planting in small grain and plowing down for corn the following year. Their yields are considerably lower, however, and it is much more practical to harvest and feed the hay, returning the manure to the land and later plowing under the aftermath. When medium red clover seed was cheaper than now and the use of sweet clover not well established, many Iowa farmers seeded red clover with their small grain to plow under the following spring for corn. Because of the lower seed cost and greater yields obtained from biennial sweet clover, this legume is now used much more generally than red clover.

Medium red clover is more valuable than mammoth red when handled in this way, for in a favorable season the medium red will often make considerable growth the first season while under the same conditions mammoth red will produce only basal leaves.

Mammoth clover, while not used extensively for hay, because of its coarse growth and tendency to lodge and mold badly, may be grown to advantage for green manure the second year on grain growing farms where little livestock is kept. One of the best practices is to roll or pull the clover down, going around the field from left to right, when, or just before, the buds or heads are forming. As the heads come out they grow erect, making it possible to cut for seed with a buncher attached to the sickle bar, leaving the bulk of the crop flat on the ground in the best position for plowing under.

Dalea, an annual, is the only one of the legumes recommended exclusively for green manure purposes because it is the only one which is not palatable, either as pasture or as hay. It became prominent in western Iowa a few years ago and is well suited for seeding in small grain to provide a green manure crop on infertile, acid soils where clovers do not succeed. Although yields of 8 to 10 tons of green manure were obtained in western Iowa on soils varying greatly in drainage, fertility, and acidity, most of the seedings made in other parts of the cornbelt were unsatisfactory. Results obtained recently indicate this difficulty may be caused by a seedling disease organism

Fig. 9. An unusually good growth of dalea in western Iowa following the harvest of a winter wheat crop. Dalea has been found to be a good annual legume for green manure on certain soils while on other soils stands are poor and the growth small. Treating the seed with the mercury dusts available on the market has been found beneficial on soils not otherwise suited to this legume.

in many soils which can be controlled by dusting the seed with one of the mercury dusts on the market. Since this legume requires dalea root-nodule bacteria in the soil for its successful use as a green manure, when seed is treated with mercury dust it is necessary to inoculate by broadcasting the proper legume bacteria in soil. This is because the bacteria may be killed by the dust if applied directly to the seed before planting. In western Iowa, land in winter wheat annually through a 20-year period has produced heavy growths of dalea, the legume volunteering from year to year and maturing a heavy crop of seed which, when plowed under, has seeded the ground for a green manure crop the following year. Under these conditions the wheat yields are reported to have improved steadily.

Korean lespedeza is not nearly as valuable as the other legumes for green manure because its growth is comparatively small. It is to be recommended only where the more valuable legumes cannot be grown successfully. It is valuable for seeding in small grain in the spring, on the more acid soils in

southern Iowa, to produce a combination late fall pasture and green manure crop.

While a discussion of soybeans is omitted from this bulletin, there is so much confusion among growers concerning the soil benefits to be derived from growing this crop, that brief mention is in order under choice of crops for green manure. In recent Iowa tests, soybeans grown as a grain crop with the straw not returned to the land did not increase the following corn crop yields when compared with corn which followed oats on other plats. Approximately 90 percent of the nitrogen and organic matter of the soybean plant is in the top growth. It is therefore apparent that a well inoculated crop of soybeans, grown and removed from the soil, either as hay or for seed, cannot but decrease the soil's nitrogen content, rather than increase it. If soybeans are to increase soil fertility, appreciably the crop must either be plowed under, or else the product—either as seed and straw or as hay—fed on the farm and the manure carefully conserved and applied to the land.

GRASSES FOR GREEN MANURE

While the grasses cannot use nitrogen from the air as do inoculated legumes, they have a definite value as green manure crops because the sod and roots increase the organic matter in the soil. Since it is always advisable to establish the grasses with legumes if at all possible, and since grasses are always sown either for hay or pasture, their use for green manure is secondary. Certain of the poorest, acid soils—where corn and small grain yield practically nothing—can be improved a certain extent by seeding them down to red top for a few years, using an acid soil legume as a companion crop. Whenever possible, however, it is advisable to improve such soils with lime, fertilizers and the more productive legumes.

COMPARISON OF WHITE SWEET CLOVER, HUBAM CLOVER AND MEDIUM RED CLOVER FOR GREEN MANURE[8]

Biennial white sweet, hubam and medium red clovers have been compared as green manure crops, sowing them in oats in a 2-year corn and oats rotation, during the 10-year period 1925-34. Two fields were used, and while oats and the clovers

[8] The work reported here was carried out in cooperation with the Soils Subsection, project No. 143.

were grown in field A, corn was grown in field B, and vice versa. Thus, from the beginning, the two fields grew corn and oats alternately, with the clovers seeded in the oats each year. Furthermore, the three kinds of clovers have always been grown on the same respective plats in each field so that a cumulative effect gradually becomes apparent.

The clovers were first seeded with oats in 1925; therefore, the corn crop of 1926 might be expected to show the effects of the green manures, while the oat crop would not be influenced until 1927. Beginning in 1922, when the experiment was started, oats and corn crops were grown in both fields in order to measure the natural yielding ability of all of the plats. Fortunately the check plats, on which legumes have never been grown, yielded slightly the highest during this preliminary period. Higher yields obtained since from the clover plats, therefore, can be credited entirely to the legumes. The fields were limed when the experiment was started, and occasional applications of superphosphate have been made. Medium red and hubam clovers have been fall plowed while biennial sweet clover has been plowed in late April or early May before planting the land to corn.

EFFECTS ON YIELDS OF CORN AND OATS

As an average for the 8-year period, 1926-33, biennial white sweet clover increased the yield of corn from 52 to 61 bushels per acre or 17 percent, hubam clover to 58 bushels or 12 percent, and medium red clover to 56 bushels or 8 percent. As an average for the seven-year period, 1927-33, oat yields were increased from 44 to 52 bushels per acre or 18 percent by the biennial white sweet clover, to 48 bushels or 9 percent by hubam clover, and to 46 bushels or 5 percent by medium red clover. The yields by years, together with averages and percentage increases are shown in table 6. No yields were obtained in 1934 because with the extreme drouth corn failed even to make a stand following biennial white sweet clover. Corn yields following hubam and medium red clovers and on check plats were estimated roughly at 10 bushels per acre, while oats failed on all plats.

The most significant fact is that on this relatively fertile Clarion soil green manure crops have consistently increased

TABLE 6—EFFECTS ON YIELDS OF CORN AND OATS OF COMMON BIENNIAL WHITE SWEET, HUBAM AND MEDIUM RED CLOVERS GROWN WITH THE OATS IN A 2-YEAR ROTATION OF CORN AND OATS

Kind of Green Manure	Bushels per acre									% increase (Av.)
	1926	1927	1928	1929	1930	1931	1932	1933	Av.	
CORN										
None (check)	57	39	59	53	31	68	64	48	52	..
Bi. white sweet clover	57	45	59	67	37	66	77	83	61	17
Hubam clover	62	39	65	63	38	65	72	64	58	12
Medium red clover	60	38	60	63	32	66	71	59	56	8
OATS										
None (check)	..	47	65	41	46	48	37	24	44	..
Bi. white sweet clover	..	54	71	55	63	48	45	31	52	18
Hubam clover	..	48	71	48	54	49	40	28	48	9
Medium red clover	..	45	55	45	54	51	41	29	46	5

yields of both corn and oats. The high fertility level of the soil is shown by the yields obtained in good years without any green manure crop. In 1931 corn yielded 68 bushels per acre without green manure, while in 1928 oats yielded 65 bushels per acre without green manure. If the soil were naturally

Fig. 11. A crop of hubam clover such as this which was seeded in the spring with small grain may either be plowed under in the fall for green manure or harvested for seed. Hubam clover is all killed by fall plowing. On 50 to 60-bushel corn soils hubam clover has increased the yield of corn an average of 12 percent and of oats 9 percent at the Iowa Station in a two-year rotation of corn and oats with hubam clover seeded in the oats.

only one-half as productive the increases would no doubt be much greater.

The results do not consistently favor biennial sweet clover over hubam and medium red in corn yields, and it was only in 1932 and 1933 that the biennial sweet clover showed a definite superiority. In the six previous years the biennial sweet clover was superior to hubam in increasing corn yields three years of the six, while hubam clover was superior to the biennial an equal number of times. Medium red clover was superior to biennial white sweet clover two of the six years and to hubam one of the six years, but it did not rank first in any year. In both 1932 and 1933 biennial white sweet, ranked first, followed by hubam and medium red clover, respectively. In 1933 biennial sweet clover increased the corn yield to 73 percent more than check (no green manure), as compared with 33 percent more than check for hubam clover and 23 percent more than check for medium red clover. The abnormally high increase for biennial white sweet clover in this one year, 1933, largely accounts for the 5 percent greater increase than hubam clover and 9 percent greater increase than medium red clover for the 8-year period.

Increases obtained in oats yields rather consistently favored biennial white sweet clover since this legume ranked first, or tied for first, six of the seven years, and in the year it did not, 1931, differences were not significant. Differences in increases in yields of oats obtained with hubam and medium red clover were not consistently in favor of either legume but favored hubam clover slightly.

Considering the amounts of dry matter returned to the soil by the three legumes, biennial white sweet clover would be expected to cause greater increases in corn yields than it did, as compared with the other two. It is believed that the biennial white sweet clover did not give greater increases largely because of the handicap it received from spring plowing in several seasons abnormally short of moisture in those seasons. If the plants of this legume could all be killed by fall plowing it is believed that larger yields would be obtained than when spring plowed. The rapidly growing sweet clover withdraws large quantities of water from the soil during April before it

is plowed under. The large amount of green manure turned under just before the corn is planted increases soil aeration, resulting in more rapid drying of the plow slice, and water is required to decay the green manure at a time it is needed by young corn plants. Definite proof of the soil-drying effect of spring plowing biennial sweet clover was obtained in 1934 when good stands of corn were obtained on the hubam and medium red clover plats, while no stands at all were obtained on the biennial white clover plats. Also, in other dry years corn on the biennial white sweet clover plats has frequently been shorter and less thrifty until mid-season than corn on the hubam and medium red clover plats.

YIELDS OF THE CLOVERS FOR GREEN MANURE

As based on the amounts of dry matter recovered in yield determinations by sampling and nitrogen analyses of these materials, biennial white sweet clover yielded more than twice as much dry matter and more than three times as much nitrogen as either of the other clovers. Average yields of dry matter and nitrogen of tops and roots and percentages of nitrogen for the years 1925-34 are given in table 7. The years 1930 and 1934 were omitted from the averages since all of the clovers failed those years because of severe drouth. Roots were dug to a depth of 10 inches each year.

TABLE 7—COMPARATIVE YIELDS OF DRY MATTER AND NITROGEN AND PERCENTAGES OF NITROGEN OF COMMON BIENNIAL WHITE SWEET, HUBAM AND MEDIUM RED CLOVERS GROWN WITH OATS FOR GREEN MANURE IN A 2-YEAR ROTATION OF CORN AND OATS. (AVERAGES OBTAINED IN TWO FIELDS FROM 1925-1934 INCLUSIVE)

Kind of green manure	Dry Matter Tons per acre			Nitrogen Pounds per acre			Nitrogen Percent			Plants per sq. yd. Av.
	Tops	Roots	Total	Tops	Roots	Total	Tops	Roots	Tops & Roots	
Bi. white sweet clover (fall)	0.83	1.01	1.84	42.1	69.0	111.1	2.54	3.43	3.03	123
Bi. white sweet clover (spring)*	1.18	0.51	1.69	94.9	34.1	129.0	4.02	3.36	3.82	140
Bi. white sweet clover (spring†)	1.60	0.51	2.11	103.8	34.3	138.1	3.24	3.37	3.28	140
Hubam clover	0.76	0.09	0.85	35.9	1.5	37.4	2.36	0.90	2.20	177
Medium red clover	0.44	0.24	0.68	23.0	11.3	34.3	2.63	2.35	2.53	150

*Including 50 percent of the dry matter and 25 percent of the nitrogen contained in the dry tops in November.

†Including all of the dry matter and nitrogen in the dry tops in November.

Yields of dry matter of biennial white sweet clover obtained in late fall and those obtained about May 1 the next spring do not differ appreciably. Spring yields must include a certain percentage of the tops which grew the previous year. Because it is not known how valuable this fall top growth is

by May 1 of the following spring, two different spring values for biennial white sweet clover are given in table 7.

Regardless of the way this old top growth is credited, it is apparent that fall and spring yields of both dry matter and nitrogen do not differ a great deal. It is believed, however, that the yields of both dry matter and nitrogen are somewhat higher May 1 than they are the previous fall. This conclusion is identical with that given in research bulletin No. 162 of the Iowa Station in 1933, which was based on an entirely different set of data.

In research bulletin No. 162 the conclusion was: "From the standpoint of amount of dry matter and nitrogen added to the soil and the eradication of the plants, sweet clover may best be plowed for corn about April 25 to May 5." It is believed that this is a logical conclusion from the data presented here, also. If the grower can eradicate the fall plowed clover effectively and economically, it is possible, because of saving moisture, that better results may be obtained by fall plowing.

Low yields of dry matter and nitrogen of hubam clover are partly accounted for by the loss of leaves which occurred before yield determinations were made. These leaves fell on the ground and were a direct contribution to the value of the crop for green manure. It is not known how much these leaves amounted to but it was considerable. It can be concluded conservatively, however, that biennial sweet clover was far superior to hubam in amount of dry matter returned to the soil.

The experiment was managed throughout in a manner similar to the way the average farmer would handle the various crops on the farm. The oat nurse crop, harvested for grain, was usually cut about 6 inches high, entirely too short for the best subsequent development of the hubam clover.

When medium red clover was first included in this experiment a considerable number of Iowa farmers were using it in this way for green manure, viz., seeding it with small grain and plowing the clover under in the fall of the same year or the following spring for corn. It seemed desirable to learn if this practice is profitable. The average increase for the red clover was 4 bushels of corn and 2 bushels of oats per year. These increases were not great but the value of the increased

corn and oats yields was more than enough to pay the cost of the red clover seed. It is apparent, however, that this is a very uneconomical way to handle medium red clover because of the crop's high value in the second year for hay or pasture.

The economical way to use medium red clover is to feed the first and second hay crops and return the manure to the land, or else to pasture the crops in accomplishing the same end. When the aftermath crop of red clover is plowed under in the late fall of the second year, it is believed that the green manure value of the residue is greater than at the end of the first year, and in addition there is the gain from the manure derived from the hay or pasture.

Biennial sweet clover can be used economically also as a combination green manure—pasture crop the second year, but experiments show that by corn planting time sweet clover has about 80 percent as much value for green manure as it has when allowed to reach its full development in the flower stage in midsummer. The two legumes, sweet clover, a biennial, and red clover, a perennial, are fundamentally different in the respect that medium red clover makes full use of the second growing season while biennial sweet clover does not.

COMPARISON OF KOREAN LESPEDEZA AND THE TRUE CLOVERS IN YIELDS OF DRY MATTER FOR GREEN MANURE

While it is generally recognized that Korean lespedeza cannot compete with the clovers on limed soils when the latter are allowed to grow throughout the second year, it was desired to learn the relative value of Korean lespedeza for green manure in the fall of the first year of growth.

Seedings of Korean lespedeza, alsike clover, mammoth red clover and medium red clover were made in April, 1932 with Spartan barley on limed, 60-bushel corn soil. The barley was cut for grain, and the yields of tops and roots of the legumes were obtained Oct. 14, the same year. Yields of dry matter for each of the legumes are shown in table 8.

Korean lespedeza, alsike clover and mammoth red clover gave similar yields of tops, each yielding about two-thirds the amount of tops as medium red clover. Typically of annual legumes, however, the Korean lespedeza gave a low root yield, only about one-fourth as much as each of the three clovers. As

Fig. 14. A good growth of Korean lespedeza in southern Iowa. Korean lespedeza is recommended for seeding in small grain in the south one-third of Iowa, on soils too acid for clovers, as a late summer and fall pasture and as a soil improving crop. It may also be seeded to advantage on thin bluegrass pasture in southern Iowa.

a total of both tops and roots medium red clover yielded 1.00 ton of dry matter per acre, mammoth red clover 0.79 of a ton, alsike clover 0.73 of a ton and Korean lespedeza 0.55 of a ton.

While it is apparent that Korean lespedeza cannot compete at Ames, Iowa, with the true clovers in dry matter yields on limed soils, even the first year, if it will make a yield of one-half ton of dry matter per acre on soils too acid to grow clovers it will be decidedly worth growing, particularly on soils low in organic matter. Korean lespedeza is a warm weather crop, and yields would be expected to be higher in southern

TABLE 8—COMPARATIVE YIELDS OF DRY MATTER OF KOREAN LESPEDEZA, ALSIKE CLOVER, MAMMOTH RED CLOVER AND MEDIUM RED CLOVER GROWN WITH BARLEY AND HARVESTED OCT. 14 OF THE SAME YEAR

Kind of green manure	Tons per acre		
	Tops	Roots	Total
Korean lespedeza	0.48	0.07	0.55
Alsike clover	0.47	0.26	0.73
Mammoth red clover	0.49	0.30	0.79
Medium red clover	0.73	0.27	1.00

Iowa under similar conditions. It is not recommended for seeding as far north as Ames.

VARIETIES AND SEED SOURCES OF LEGUMES AND GRASSES

Selection of the best variety or source of seed of some of the legumes is as important as choosing the best crop for a particular soil or purpose. Varieties and seed sources of alfalfa, biennial sweet clovers and red clover have been investigated extensively at the Iowa Station since 1925. These tests have been conducted cooperatively with the Division of Forage Crops and Diseases of the United States Department of Agriculture. This cooperation has made it possible to test seed samples from practically all seed producing states and foreign countries. Other investigations have included tests of kinds, varieties or sources of white clover, lespedeza, timothy and reed canary grass. There are no varieties of alsike clover and comparison of seed sources for this legume have not been conducted. Variety isolation and seed source investigations with field grasses of importance in Iowa, other than for timothy and reed canary grass, have received only minor consideration in the United States.

ALFALFA

Alfalfa bacterial wilt infestation has complicated the varietal recommendations for Iowa since about 1925. This is a disease that causes the plants to sicken and die here and there over the field, gradually thinning the stand. The disease seems to be rather general in the older and larger alfalfa producing sections of western Iowa but not so common in sections where alfalfa is a comparatively new crop. Fortunately, effects of the disease, are not usually noticeable until the second or third crop year. At the Iowa Station the disease has always been apparent first in the lower parts of fields.

On the Iowa Experiment Station fields, where the soils are all infected with the wilt bacteria, effects of the disease are avoided easily—even when susceptible varieties are grown—by use of the short rotation system. It is planned to have a field, thus, in alfalfa for only two, or at most three, crop seasons with a new field coming on to take its place. With this system common alfalfa from the Dakotas and Montana has giv-

en just as good results as the variegated alfalfas, such as Grimm, Cossack, Baltic and Hardigan. Common alfalfa from northwest Nebraska counties bordering on South Dakota is nearly as good as that from the Dakotas and Montana, while that coming from Kansas, Idaho, Utah, Oklahoma and New Mexico has yielded somewhat less hay and is much more likely to be killed by cold in severe winter when there are many alternate freezes and thaws with little snow covering.

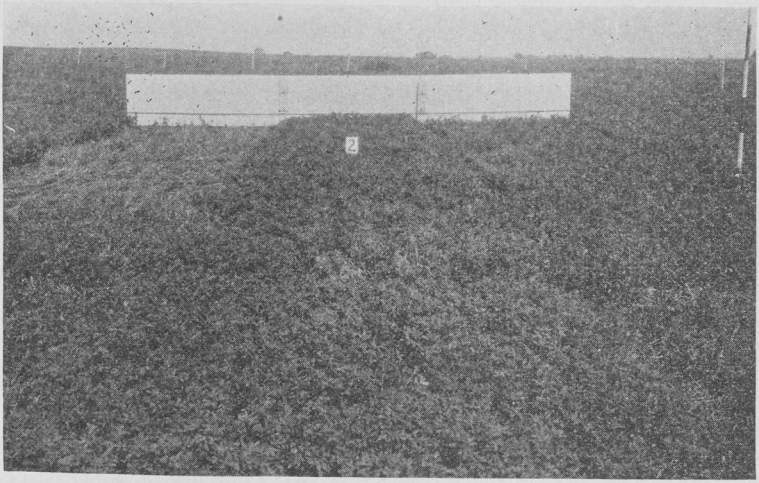

Fig. 12. A view in the alfalfa variety test plots at Ames. The selection of the best variety or source of seed of some of the legumes is as important as choosing the best crop for a particular soil or purpose. Grimm alfalfa in the center (in front of the board) shows excellent stand and growth, while New Mexico common the left was nearly all winterkilled and Utah common on the right was thinned by winterkilling, and severely winter injured as indicated by the small, sparse growth.

At present there is no satisfactory bacterial wilt resistant alfalfa variety. Imported Turkistan is highly resistant to both bacterial wilt and cold but the plants are subject to leaf diseases which, combined with slow growth, reduce the yield so that it produces about a ton of hay per acre less than the recommended variegated and common alfalfas as a total of two or three crop seasons. This difference is more than enough to pay the cost of seeding a new field when the greater fertilizing value of the alfalfa residue in the short rotation is considered. On the other hand, while the Iowa tests are inadequate, it is probable that Turkistan will maintain a satisfactory

stand, 4, 5 or 6 years even when the wilt organism is present. Apparently, Turkistan has a place in Iowa for those growers who are willing to sacrifice yield to gain longevity.

Hardistan is a wilt resistant variety of Turkistan origin recently distributed by the Nebraska Station. Preliminary tests at the Iowa Station indicate that it may be superior to the average lot of imported Turkistan, particularly in resistance to leaf diseases. Essentially, however, it is similar to Turkistan. Special attention is directed to this variety because Turkistan seed has been excluded by high federal tariff and other factors during the last few years and has not been obtainable. The variety name Hardistan should be distinguished carefully from that of Hardigan, an entirely different alfalfa variety developed at the Michigan Station which—while winter hardy—is susceptible to bacterial wilt, like Grimm.

The most satisfactory varieties of alfalfa for Iowa farms where the bacterial wilt disease has not been observed are the variegated sorts Grimm, Cossack, Ladak, Baltic and Hardigan, while common alfalfa from the Dakotas and Montana should give results nearly as good, according to Iowa Station tests. There is little to choose among the variegated varieties. Ladak has given somewhat the highest yields and is more cold and heaving resistant than the others, but produces light second, and especially third, crops. It becomes dormant early in the fall thus giving weeds and bluegrass opportunity to encroach. Ladak has been found to be somewhat resistant to bacterial wilt in the Iowa tests. Baltic is essentially similar to Grimm, but comparatively little seed is produced. Hardigan appears to be slightly inferior to Grimm but blooms most abundantly of any of the alfalfas and may be expected, thus, to set more seed in Iowa than the others. Variegated alfalfas, as a group, bloom and set seed better in Iowa than common alfalfa. It is believed, therefore, that most of the small amount of seed grown in Iowa is produced by Grimm or Cossack or one of the other variegated varieties.

The variegated alfalfas are so termed because they have variously colored flowers while common alfalfa generally has only purple flowers, though varying in shade from light to dark. Common alfalfa from the Dakotas, Montana, and adjoining dis-

tricts in Nebraska and Wyoming usually has a little variegated mixture, which may be the reason that it is hardier than common from other states. The flower colors offer practically the only distinguishing characteristics among kinds, and since alfalfas bloom comparatively little in Iowa the different varieties can be distinguished with difficulty even by a specialist experienced in working with them. Buyers, therefore, need to be discriminating in the purchase of seed. Only **certified** seed of the variegated alfalfas Grimm, Cossack, Ladak, Baltic and Hardigan should be purchased. This is offered only in sealed bags, bearing a certified label as to variety and quality. Only **verified origin** seed of common alfalfa should be purchased. This seed bears a red, white and blue tag, which is a guarantee of the federal government that the seed was grown in the state named on the tag. While it is important to know the state in which common alfalfa seed is produced, Iowa tests indicate that genuine certified seed of the variegated alfalfas from any state is as good as that from others. It would seem, however, that some states are more careful in their certification procedure than others.

Imported seed other than that coming from Canada and Turkistan should be avoided. Canadian seed is stained 1 percent violet while Turkistan is stained 10 percent purple-red. Argentina seed is stained 10 percent orange-red. Imported seed from other sources is stained either 10 percent red or 1 percent green.

SWEET CLOVER

There are many so-called varieties, strains or species of sweet clover, but the only ones which most Iowa growers choose from are common biennial white—sometimes referred to as "late white"—Grundy County White, common biennial yellow and hubam.

As a general purpose crop the common biennial white is believed to be superior to the Grundy County White or the common biennial yellow because it produces more top growth for pasture both the first and second seasons, and because it is considerably later in maturing. Pasture, thus, is furnished until later in the second year.

In all readily apparent plant characteristics except color of flowers Grundy County White and common yellow are much more nearly alike than Grundy County White and the common white. The former blossom and ripen seed at about the same time, and both yield more seed than the common white. They seem to be fairly similar, also, in yield of tops and roots. Since these two kinds, Grundy County White and common yellow, are so similar it is unfortunate that the Grundy County White was ever originated. Since it yields more seed than the common white, and the seed crop can be harvested more easily because of the smaller size of plants, it is becoming increasingly difficult to buy genuine common white seed. The most unfortunate point is that the average grower, lacking common white with which to compare, does not know whether he is growing common white or Grundy County White since the differences in time of flowering and seed ripening are the only distinguishing characteristics.

Iowa Late White sweet clover, tested by the Iowa Station, is 10 days later in flowering than the common white, and produces much more top growth. It was distributed for the first time in the spring of 1935. Because of its lateness, Iowa Late White will extend the pasturing season at least two weeks in the second year. Preliminary tests indicate that when seed crops are desired it should either be pastured in the early season, or else clipped back to a height of about 16 inches with a binder before buds begin to appear. This reduces the amount of vegetative growth and favors the setting of seed. It is expected that seed of an even later strain, Chantland Late White, selected from the Iowa Late White by Mr. T. A. Chantland, Badger, Iowa, will be available for distribution in about 1937.

There are no different varieties of hubam (the annual white sweet clover) now available. Annual yellow, which volunteers in small grain in the southwest, is worthless under Iowa conditions. Redfield yellow is a late type of biennial yellow but does not appear to be as good as Iowa Late White in Iowa. Arctic is much earlier and smaller growing than Grundy County White or common yellow and does not have a place in Iowa. Albotrea is a so-called variety of biennial yellow that has not appeared to be essentially different from the common

yellow in Iowa Station tests. Alpha sweet clover, originated in Canada, does not make enough growth under Iowa conditions to compete with the better kinds.

RED CLOVER

While as yet there are no established varieties of medium red clover suitable for Iowa conditions, extensive Iowa Station tests have demonstrated that seed source has a great influence on the resulting crop. The only seed, in general, that needs be avoided for Iowa use is that imported from any countries except Canada, and seed grown from established stocks in western Oregon and Washington. Canadian seed is stained 1 percent violet while other imported seed is stained either 1 percent green or 10 percent red. Seed verified as to state of origin is available, as for alfalfa.

Seed produced in Canada and all northern states is satisfactory in Iowa. Tests indicate, however, that seed produced from old, established Iowa strains, grown in the same communities in this state for 15-50 years, are somewhat superior to strains from other localities. Likewise, tests at other stations indicate that their old, established strains are best for those states. Differences, however, among old strains from the several states tested at the Iowa Station are not great. The old, established Iowa strains show some superiority over red clover grown from seed produced in Idaho, Colorado and other Rocky Mountain states. The old, established strains from Iowa, Missouri, Illinois and Ohio appear to be slightly superior to strains from North Dakota, Minnesota, Wisconsin, Michigan and Canada in that the second crops make more growth, and mature later.

American mammoth red clover, with seed produced in the northern part of the United States, has been compared with various types of mammoth (single-cut clovers) from foreign countries. These tests indicate that the American mammoth is preferable from the standpoints of production and freedom from disease and insect injury.

WHITE CLOVER

There are three recognized agricultural forms of white clover, White Dutch—commonly referred to simply as white clover—ladino and the wild white of England. White clover found

Fig. 13. A good growth of white clover on a bluegrass sod. This clover comes and goes in many bluegrass pastures, often being plentiful in wet years and scarce in dry ones. While medium red, alsike and sweet clovers are much more productive it is advisable to include 2 pounds per acre of white clover in the seeding mixture intended for semi-permanent pasture. Clovers raise the nutritive value of the pasture and stimulate growth of the grasses.

growing wild in the United States apparently is the same as the common white clover, but experiments now in progress indicate that there may be differences in performance between white clover from different parts of the United States. The wild white of Europe is smaller growing than the American white clover, and is in high favor in Europe for pasture. In tests at the Iowa station it has not been as productive and has not lived any longer than the common white clover.

Ladino is a giant form of white clover, producing nearly as much forage as alsike clover. It is valued highly in some of the western states, especially when grown under irrigation, but has not been sufficiently winter hardy in Iowa tests to warrant its recommendation here.

LESPEDEZA

While there are 17 species of lespedeza native to the United States—all perennials—not one of them is recognized as valuable as a cultivated crop. All of the valuable lespedezas have come from the Orient.

The annual Korean lespedeza *(L. stipulacea)* is the only

commercially available kind that has shown promise in Iowa, and its value seems to be confined to the southern one-third of the state because it does not produce seed consistently farther north. Its growth is relatively small in central and northern Iowa. An early, abundant seed producing strain of the common lespedeza *(L. striata)* sometimes erroneously called "Japan clover," has ripened seed at the Iowa station consistently, but apparently it does not make enough growth in the field to be of much value. A very early strain of the Korean called Harbin apparently is worthless in Iowa because of small growth. It ripens seed in August and early September and, therefore, does not make full use of the growing season. Another early Korean strain, midway in maturity between the ordinary Korean and Harbin, ripens seed at Ames, and makes full use of the growing season. In preliminary tests it has given some promise of being superior to the ordinary Korean in central Iowa and possibly in southern Iowa. Common lespedeza of the South and the different varieties of it are too late to be of value in Iowa.

Perennial lespedeza *(L. sericea)* winterkilled one year out of four at the Iowa Station. It has made satisfactory growth in rows, but stands were not obtained with a broadcast seeding made with small grain in 1933. It is doubtful if this legume will have a place in Iowa, but further testing is required, particularly on the acid soils of southern Iowa. It has considerable promise as a substitute crop for alfalfa on the acid soils of the southern states.

TIMOTHY AND REED CANARY GRASSES

Several timothy varieties have been developed by the United States Department of Agriculture and state experiment stations including the Iowa Station. These varieties differ from ordinary timothy in maturity time, leafiness, stooling, amounts of forage produced, and disease resistance. Apparently none of these varieties is now grown in the state, and Iowa Station tests to determine their relative value have been inadequate.

Seed of a variety of reed canary grass, known as Iowa Reed Canary grass, developed from breeding work at the Iowa station continued through a 12-year period, has been distributed to a few growers for increase. Seed is not as yet available

Fig. 15. A good growth of reed canary grass on the experiment station fields at Ames. This grass is especially recommended for poorly drained, semi-swampy lands but has given yields 50 percent greater than the other hay grasses on upland soils. On uplands it is driven out by Kentucky bluegrass when pastured closely. In pure stands on uplands it becomes "sod bound" and unproductive after a few years.

commercially. Preliminary trials indicate that this variety is superior in forage and seed production to common reed canary grass. Other varieties are in process of being established by other states. Considerable testing at the Iowa Station indicates that common reed canary grass seed from Minnesota and the Pacific Northwest may be expected to give similar results in Iowa.

RAPE

There are several varieties of rape, but Dwarf Essex is practically the only one grown for forage. Most of the rape seed used in the United States is imported from Europe, but within recent years some seed has come from the Orient. Observations made in other states indicate that the Dwarf Essex from Europe is likely to be superior to that from other sources.

PRACTICES IN ESTABLISHING STANDS[9]

Usually it pays to buy the best quality of seed, free from weeds and inert material and of high germination. The Iowa

[9] For a detailed discussion, accompanied by data, of practices in establishing stands of the legumes and perennial grasses the reader is referred to Iowa Agricultural Experiment Station Bulletin "Establishing Legumes and Perennial Grasses," a companion publication soon to be published. Only a brief summary of procedure is given here.

seed law requires that information concerning quality, germination and source of the seed be given on the labels.

A saving can sometimes be effected, in purchasing second or third grades of **certified** seed such as alfalfa, since these grades are standardized, and frequently are only slightly inferior in quality to the first grade, with no difference in assurance of the genuineness of the variety represented. Biennial sweet and hubam clover seed should be hulled and scarified when purchased unless these clovers are to be seeded during the winter. Alfalfa and the true clovers may be injured more than improved by scarifying, but certain "hard" lots of alfalfa are improved by scarifying. Korean lespedeza is usually not hulled before planting. It has a high percentage of hard seed in the fall, but this condition disappears as planting time approaches. Dalea seed should be scarified.

Legume seed should be inoculated unless it is known that root-nodule bacteria for the legume in question are already present in the soil. It usually is necessary to inoculate alfalfa and sweet clover on soils where neither of these crops has been grown successfully in previous years. The bacteria for the true clovers—medium and mammoth red, alsike and white clover—are usually present in Iowa soils. It is believed that the cause of many failures of Korean lespedeza in southern Iowa has been the lack of proper bacteria for this legume. Dalea requires still another kind of bacteria. Cultures, or one of the soil methods of inoculation, may be used.

Legumes and grasses require a firm seedbed for their best early development. For this reason the best seedbeds can usually be prepared following a cultivated crop without plowing. Soybeans leave the soil unusually loose and when this crop precedes legumes and grasses, it is desirable to roll at least twice after seeding in order to firm the soil about the small seeds. If the preceding soybean crop was seeded solid, like small grain, it is best to drill in both nurse crop and legumes or grasses without discing and follow by rolling.

Weed control is important in establishing stands. Iowa Station tests have demonstrated that the best procedure is to keep the preceding cultivated crop entirely free from weeds. Then, if the soil is only lightly disced so that buried weed seed are

not brought to the surface, little weed competition results. Plowing brings buried weed seed to the surface in large numbers where they are ready to compete with the legumes or grasses.

SEEDING

Suggested rates of seeding the different legumes and grasses in pure seedings and mixed combinations for different conditions and purposes are given in table 9. This table is presented only as a guide. The grower is advised to use his own discretion for his particular needs or conditions.

In general, the best time of seeding the small seeded legumes and grasses is in early spring because temperature and moisture conditions are more likely to be satisfactory. Good results usually are obtained from June and July seedings, however, if the land is plowed in April and then fallowed and weeds are killed as they begin growth. May seedings are apt to suffer from weed competition because most annual weed seed germinate during this month. August seeding is too late for best results with the legumes and is not advised unless for some reason it is impossible to make seedings earlier. Alfalfa and sweet clover seeded in August usually will make satisfactory stands and survive the winter, but yield less hay or pasture the next year than when seeded earlier in the season. Grasses withstand later seeding than the legumes. Timothy and bluegrass, for example, are frequently seeded in September with satisfactory results.

The early spring seedings usually are made with a nurse crop. If winter grain is used the legume or grass seed may be broadcast about March 15 to 25, in which case covering is unnecessary, but rolling as soon as the soil is dry enough is beneficial. If oats, barley, spring wheat, or flax is used these crops may best be seeded as soon as the soil is dry enough to be worked the last of March or early part of April. When these crops are used the ordinary procedure is to disc in the nurse crop, broadcast the legume or grass seed and then harrow once, or preferably twice. Excellent results have always been obtained at the Iowa Station by first drilling in the nurse crop and then cross drilling the legume or grass. Regardless of method used, seeding deeper than three-fourths inch should

TABLE 9—SUGGESTED INGREDIENTS AND AMOUNTS OF SEED PER ACRE FOR DIFFERENT PURPOSES AND DIFFERENT SOIL CONDITIONS. The proportion of each ingredient used may be varied considerably with perhaps equally good results. A total seeding of 12 to 15 pounds of seed per acre is usually advisable for mixtures but even less probably will suffice, particularly on the more fertile, limed soils. As ingredients are added to the mixture for seeding the semi-permanent pasture, amounts of other ingredients may be reduced

	Alfalfa	Biennial sweet clover	Hubam clover	Medium red clover	Alsike clover	White clover	Korean lespedeza (unhulled)	Dalea	Rape	Timothy grass	Kentucky bluegrass	Red top grass	Brome grass	Reed canary grass	Orchard grass
Pure seedings (for any purpose)	15	10	10	10	5	..	12	10	6	15	..	10	20	8	20
Pasture Mixtures—short rotation															
Soils sweet over entire field	....	7	....	3	....	....	....	....	....	5	....	....	....	....	....
Soils sweet in parts, slightly acid in others	....	4	....	5	....	....	....	....	1½	5	....	....	....	....	....
Soil acid, 1 to 2½ ton lime requirement	....	2	....	5	2	....	....	....	1½	5	....	....	....	....	....
Soil acid, over 2½ ton lime requirement; north ⅔ Ia.	....	....	....	4	3	....	....	....	1½	7	....	....	....	....	....
Soil acid, over 2½ ton lime requirement; south ⅓ Ia.	....	....	....	4	2	....	6	....	1½	5	....	....	....	....	....
Meadows (Hay)															
Soil sweet over entire field	15*	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Soil slightly acid (1 ton lime requirement)	8	....	....	4	....	....	....	....	....	4–7	....	....	....	....	....
or	....	....	....	8	....	....	....	....	....	4	....	....	....	....	....
Soil acid, 1 to 2½ ton lime requirement	....	....	....	6	2	....	....	....	....	7	....	....	....	....	....
Soil acid, over 2½ ton lime requirement†	....	....	....	3	3	....	....	....	....	7	....	....	....	....	....
Green Manure															
Soil sweet over entire field	....	10‡	....	....	....	....	....	....	....	....	....	....	....	....	....
Soil sweet in parts, slightly acid in others	....	5‡	....	5	....	....	....	....	....	....	....	....	....	....	....
Soil acid, 1 to 2½ ton lime requirement	....	2‡	....	9	....	....	....	or dalea alone at 10 lbs.							
Soil acid, over 2½ ton lime requirement; north Iowa	....	....	....	4	3	....	....	or dalea alone at 10 lbs							
Soil acid, over 2½ ton lime requirement; south ⅓ Ia.	....	....	....	4	4	....	6	or dalea alone at 10 lbs.							

Pasture Mixtures—semi-permanent

1. On fertile to average soil add 3 to 7 lbs. Kentucky blue grass and 2 lbs. white clover per acre to short rotation mixture.
2. On very infertile soils add 3 lbs. Kentucky blue, 3 lbs. red top and 2 lbs. white clover to short rotation mixture.
3. On poorly drained soils add 3 lbs. reed canary, 2 lbs. red top and 2 lbs. alsike clover to short rotation mixture if not already indicated.
4. In northwest Iowa include in 1 (above) an addition of 3 lbs. of brome grass.
5. Some red top, brome, reed canary or orchard can be substituted for part of timothy in any mixture.
6. Three to 5 lbs. of alfalfa can be used in place of part of clover on sweet or partly sweet soils.

For reseeding permanent pastures

Use legumes as indicated for "pasture mixtures—short rotation" but omit rape and timothy. On soils too poor for Kentucky blue grass include 5 lbs. red top if none is growing in the field.

*(Add 4 to 7 lbs. of timothy if soil is bacterial wilt infected.)

†If to be turned into semi-permanent pasture see 1, 2, 3, 4, or 5 under "Pasture Mixtures—semi-permanent.

‡Hubam may be used in place of biennial sweet clover if it is to be fall plowed.

Fig 16. A good growth of rape following the harvest of a crop of oats. Every acre of small grain not seeded with clover may well be seeded to this productive, nutritious and palatable forage. The cost of seeding, at 5 to 7 pounds per acre, is always low. When clover is seeded with small grain to be used for pasture the total yield of forage is increased by adding 1½ pounds of rape seed per acre.

be avoided in most soils. It is always avisable to roll the ground after seeding clover or grass.

NURSE CROPS

The best nurse or companion crops are short, erect growing and non-lodging, mature early, have few leaves, do not stool thickly and remove comparatively small quantities of water from the soil. Spartan barley comes the nearest to fulfilling these requirements of any nurse crop harvested for grain in tests at the Iowa Station. Flax, Iowa 105 oats, and other varieties of barley are good. Other early maturing oats such as Iowa 103 and Iogold are satisfactory. The mid-season oats of the Silvermine, Swedish Select, and Green Russian type are poor. Spring wheat is fair, while winter wheat and winter rye are poor on fertile soils. Spring sown winter wheat or winter rye, are excellent nurse crops but they do not head and can be used only for pasture.

It is advisable to reduce the rate of seeding the nurse crop a third, or even a half, and it is good cultural practice either to cut the nurse crop for hay shortly after it has headed, when in the early milk stage, or to pasture it off. The nurse crop with which sweet clover is seeded should be cut at least 6 inches high, and 11 inches or higher is best for hubam clover. For other legumes or grasses 3 inches or higher is satisfactory.

Legume or grass seedings made at any time other than early spring can be started best without a nurse crop, except when it is advantageous to seed grasses in September with fall sown grain, or when it is advisable to sow some grain to hold the soil against washing or blowing. If it is known that the early spring sown legumes and grasses will not have weed competition and the small grain is regarded as of incidental importance, it is better to omit the nurse crop in order to avoid competition for moisture.

In order for new seedings of legumes or grasses to develop strong root systems, the leaves must be allowed to develop. With more leaf development there will be more root development, followed by larger crops later. New seedlings in pastures need to be allowed to make a reasonable growth and establish themselves the first year. It is often advisable, therefore, to supplement the grass pasture with sudan grass or other kinds of emergency pasture. Sweet clover keeps growing from seeding time until killed by November freezes, and any interruption interferes with root development. Alfalfa seedlings, on the other hand, established in early spring, mature in July or August when new growth starts from the crowns. It is believed that cutting at this time to remove weeds is not harmful, and Ohio tests recently reported substantiate this opinion. If weeds are not present, however, it is preferable not to cut the crop during the seedling year. Also, unless pasturing is done lightly and discontinued before Sept. 1 it may weaken the plants. Mowing the seedling crop of red clover in mid-August is beneficial, according to Illinois Station tests. The young red clover reaches its full development at that time and sometimes blooms.

RESEEDING

Many inquiries concerning the reseeding of spotted stands are received annually. First, is it highly desirable to learn why the seedings failed and to correct the condition if possible. If it is because of lack of lime or fertility these deficiencies can be corrected. Reseedings can be made at times and in ways similar to those recommended for initial seedings. At the Iowa Station excellent results in reseeding spots in new alfalfa fields have been obtained by simply drilling in the seed

just deep enough to cover as the first spring operation. If a drill is not available the seed can be broadcast and covered with a light discing followed by harrowing. Rolling is highly desirable if the soil is sufficiently dry. When thin stands are thickened, the year-old plants are not greatly injured by a light discing, but drilling is less injurious. Trying to prolong the life of an old alfalfa field by reseeding is not usually advisable except on hilly land. Generally it is a much better practice to use the seed in establishing a new field.

In reseeding pastures the best results are obtained by drilling the seed in late March as soon as the soil is thawed a few inches. The earlier the seedlings get started, the better they can compete with the grass and other plants, and also the more pasturing they can withstand the first season. In the absence of a drill the broadcast seed can be covered with a light discing. Experiments show that good stands are seldom obtained in pastures unless the seed is given some cover. Also, reseeding is useless unless the young plants are given considerable opportunity to grow and become established during the first season. Reseeding legumes is not advisable if the Kentucky bluegrass sod is thick and heavy since the legumes will not grow satisfactorily with this kind of competition.

SUGGESTED READINGS

Publications listed are available and may be obtained from the different state colleges, experiment stations or the United States Department of Agriculture. Single copies are sent free upon request except that 5 cents is charged for each of the two U.S.D.A. bulletins preceded by (5c) and 10 cents for the one preceded by (10c). In addition mimeographed information on subjects pertaining to legumes and grasses may be obtained free from the Division of Forage Crops and Diseases, United States Department of Agriculture, Washington, D. C.

Alfalfa

Extension Circular 211, Iowa State College, Ames.
Exp. Sta. Bulletin 305, Iowa Agricultural Experiment Station, Ames.
Exp. Sta. Bulletin 540, Ohio Agricultural Experiment Station, Wooster.
Exp. Sta. Bulletin 349, Illinois Agricultural Experiment Station, Urbana.
Farmers' Bulletin 1722, U. S. Department of Agriculture, Washington, D. C.
Farmers' Bulletin 1731, U. S. Department of Agriculture, Washington, D. C.

Alsike Clover

Farmers' Bulletin 1151, U. S. Department of Agriculture, Washington, D. C.

Lespedeza

Extension Circular 289, University of Missouri, Columbia.
Exp. Sta. Bulletin 331, Missouri Agricultural Experiment Station, Columbia.
Exp. Sta. Circular 163, Kansas Agricultural Experiment Station, Manhattan.
Exp. Sta. Bulletin (in press), Illinois Agricultural Experiment Station, Urbana.

Red Clover

U.S.D.A. Leaflet 110, U. S. Department of Agriculture, Washington, D. C.
Extension Circular 199, University of Wisconsin, Madison.

Sweet Clover

Research Bulletin 162, Iowa Agricultural Experiment Station, Ames.
Exp. Sta. Bulletin 405, Ohio Agricultural Experiment Station, Wooster.
Extension Circular 134, University of Nebraska, Lincoln.
Exp. Sta. Bulletin 394, Illinois Agricultural Experiment Station, Urbana.
Farmers' Bulletin 1653, U. S. Department of Agriculture, Washington, D. C.
(5c) Technical Bulletin 380, U. S. Department of Agriculture, Washington, D. C.
Leaflet 23, U. S. Department of Agriculture, Washington, D. C.

Brome Grass

(5c) Technical Bulletin 307, U. S. Department of Agriculture, Washington, D. C.

Grasses (General)

Farmers' Bulletin 1254, U. S. Department of Agriculture, Washington, D. C.
Farmers' Bulletin 1433, U. S. Department of Agriculture, Washington, D. C.

Orchard Grass

Exp. Sta. Circular 172, Missouri Agricultural Experiment Station, Columbia.

Red Top

Exp. Sta. Bulletin 404, Illinois Agricultural Experiment Station, Urbana.

Reed Canary Grass

Farmers' Bulletin 1602, U. S. Department of Agriculture, Washington, D. C.
Extension Bulletin 137, College of Agriculture, University of Minnesota, St. Paul.
Extension Circular 120, University of Wisconsin, Madison.

Timothy

Farmers' Bulletin 990, U. S. Department of Agriculture, Washington, D. C.
Leaflet 99, U. S. Department of Agriculture, Washington, D. C.

Pastures (General)

(10c) Miscellaneous Publication 194, U. S. Department of Agriculture, Washington, D. C.
Exp. Sta. Bulletin 253, Kansas Agricultural Experiment Station, Manhattan.
Exp. Sta. Bulletin 414, Wisconsin Agricultural Experiment Station, Madison.
Extension Circular 102, University of Nebraska, Lincoln.

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